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BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)
BACKGROUND DOCUMENT FOR
K103 AND K104

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EXECUTIVE SUMMARY

BDAT Treatment Standards for K103 and K104

Pursuant to section 3004(m) of the Resource Conservation and Recovery Act as enacted by the Hazardous and Solid Waste Amendments on November 8, 1984, the Environmental Protection Agency (EPA) is establishing best demonstrated available technology (BDAT) treatment standards for the listed wastes identified in 40 CFR 261.31 as K103 and K104. Compliance with these BDAT treatment standards is a prerequisite for placement of the waste in units designated as land disposal units according to 40 CFR Part 268. The effective date of these treatment standards is August 8, 1988.

This background document provides the Agency's rationale and technical support for selecting the constituents to be regulated in the K103 and K104 wastes and for developing treatment standards for those regulated constituents. The document also provides waste characterization and treatment information that serves as a basis for determining whether variances may be warranted.

EPA may grant a treatment variance in cases where the Agency determines that the waste in question is more difficult to treat than the waste upon which the BDAT treatment standard is based.

The introductory section, which appears verbatim in all the First Third background documents being issued at this time, summarizes the Agency's legal authority and promulgated methodology for establishing treatment standards and discusses the petition process necessary for requesting a variance from the treatment standards. The remainder of the document presents waste-specific information--the number and locations of facilities affected by the land disposal restrictions for the K103 and K104 wastes, the waste-generating process, characterization data, the technologies used to treat the waste (or similar wastes), and available performance data, including data on which the treatment standards are based. The document also explains EPA's determination of BDAT, selection of constituents to be regulated, and calculation of treatment standards.

According to 40 CFR 261.32, waste codes K103 and K104, which are generated by the nitrobenzene and aniline industries, are listed as follows:

K103: Process residues from aniline extraction from the production of aniline.

K104: Combined wastewater streams generated from nitrobenzene/aniline production.

EPA has estimated that six facilities in the nitrobenzene and aniline industries are potential generators of the K103 and K104 wastes. Generators of K103 and K104 generally fall under Standard Industrial Classification (SIC) code 2869 (nitrobenzene/aniline).

Treatment standards are established for both nonwastewater and wastewater forms of K103 and K104. (For the purpose of determining the applicability of the treatment standards, wastewaters for K103 and K104 are defined as wastes containing less than 1 percent (weight basis) total suspended solids* and less than 4 percent (weight basis) total organic carbon (TOC).) Waste not meeting this definition must comply with the treatment standards for nonwastewaters.

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* The term "total suspended solids" (TSS) clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, total suspended solids is measured by method 209C (Total Suspended Solids Dried at 103-105°C) in Standard Methods For the Examination of Water and Wastewater, 16th edition.

For K103/K104 wastewater, the Agency is establishing treatment standards for aniline, benzene, 2,4-dinitrophenol, nitrobenzene, and phenol. A treatment standard is also established for total cyanides in K104. The treatment standards are based on a treatment train consisting of liquid/liquid extraction followed by steam stripping and activated carbon adsorption.

For K103/K104 nonwastewater, the Agency is establishing treatment standards for aniline, benzene, 2,4-dinitrophenol, nitrobenzene, and phenol. A treatment standard is also established for total cyanides in K104. The treatment standards are based on performance data from rotary kiln incineration. Performance data were transferred from K019 for benzene, aniline, 2,4-dinitrophenol, nitrobenzene, and phenol, and from K048/K051 for total cyanides.

The following table presents the treatment standards for K103 and K104 wastes. The treatment standards are total composition and reflect the concentration of constituents in the waste. The units are mg/l (parts per million on a weight-by-volume basis) for wastewater and mg/kg (parts per million on a weight-by-weight basis) for nonwastewater. If the concentrations of the regulated constituents in K103 and K104 wastes, as generated, are lower than or equal to the proposed BDAT treatment standards, then treatment is not necessary as a prerequisite to land disposal.

BDAT Treatment Standards for K103

	Maximum for any single grab sample		
	Nonwastewater		Wastewater
Constituent	Total concentration (mg/kg)	TCLP leachate concentration (mg/l)	Total concentration (mg/l)
Volatile Organics			
Benzene	6.0	NA	0.15
Semivolatile Organics			
Aniline	5.6	NA	4.5
2,4-Dinitrophenol	5.6	NA	0.61
Nitrobenzene	5.6	NA	0.073
Phenol	5.6	NA	1.4

NA = Not applicable.

BDAT Treatment Standards for K104

Constituent	Maximum for any single grab sample		
	Nonwastewater		Wastewater
	Total concentration (mg/kg)	TCLP leachate concentration (mg/l)	Total concentration (mg/l)
Volatile Organics			
Benzene	6.0	NA	0.15
Semivolatile Organics			
Aniline	5.6	NA	4.5
2,4-Dinitrophenol	5.6	NA	0.61
Nitrobenzene	5.6	NA	0.073
Phenol	5.6	NA	1.4
Inorganics			
Cyanides (total)	1.8	NA	2.7

NA = Not applicable.

1. INTRODUCTION

This section of the background document presents a summary of the legal authority pursuant to which the best demonstrated available technology (BDAT) treatment standards were developed, a summary of EPA's promulgated methodology for developing the BDAT treatment standards, and, finally, a discussion of the petition process that should be followed to request a variance from the BDAT treatment standards.

1.1 Legal Background

1.1.1 Requirements Under HSWA

The Hazardous and Solid Waste Amendments of 1984 (HSWA), which were enacted on November 8, 1984, and which amended the Resource Conservation and Recovery Act of 1976 (RCRA), impose substantial new responsibilities on those who handle hazardous waste. In particular, the amendments require the Agency to promulgate regulations that restrict the land disposal of untreated hazardous wastes. In its enactment of HSWA, Congress stated explicitly that "reliance on land disposal should be minimized or eliminated, and land disposal, particularly landfill and surface impoundment, should be the least favored method for managing hazardous wastes" (RCRA section 1002(b)(7), 42 U.S.C. 6901(b)(7)).

One part of the amendments specifies dates on which particular groups of untreated hazardous wastes will be prohibited from land disposal unless "it has been demonstrated to the Administrator, to a reasonable degree of certainty, that there will be no migration of hazardous constituents from the disposal unit or injection zone for as long as the wastes remain hazardous" (RCRA section 3004(d)(1), (e)(1), (g)(5), 42 U.S.C. 6924 (d)(1), (e)(1), (g)(5)).

For the purpose of the restrictions, HSWA defines land disposal "to include, but not be limited to, any placement of . . . hazardous waste in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, or underground mine or cave" (RCRA section 3004(k), 42 U.S.C. 6924(k)). Although HSWA defines land disposal to include injection wells, such disposal of solvents, dioxins, and certain other wastes, known as the California List wastes, is covered on a separate schedule (RCRA section 3004(f)(2), 42 U.S.C. 6924 (f)(2)). This schedule requires that EPA develop land disposal restrictions for deep well injection by August 8, 1988.

The amendments also require the Agency to set "levels or methods of treatment, if any, which substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste so that short-term and long-term threats to human health and the environment are minimized" (RCRA section 3004(m)(1), 42 U.S.C. 6924 (m)(1)). Wastes that satisfy such levels or methods of treatment established by EPA, i.e., treatment standards, are not prohibited from being land disposed.

In setting treatment standards for listed or characteristic wastes, EPA may establish different standards for particular wastes within a single waste code with differing treatability characteristics. One such characteristic is the physical form of the waste. This frequently leads to different standards for wastewaters and nonwastewaters. Alternatively, EPA can establish a treatment standard that is applicable to more than one waste code when, in EPA's judgment, a particular constituent present in the wastes can be treated to the same concentration in all the wastes.

In those instances where a generator can demonstrate that the standard promulgated for the generator's waste cannot be achieved, the amendments allow the Agency to grant a variance from a treatment standard by revising the treatment standard for that particular waste through rulemaking procedures. (A further discussion of treatment variances is provided in Section 1.3.)

The land disposal restrictions are effective when promulgated unless the Administrator grants a national variance and establishes a different date (not to exceed 2 years beyond the statutory deadline) based on "the earliest date on which adequate alternative treatment, recovery, or disposal capacity which protects human health and the environment will be available" (RCRA section 3004(h)(2), 42 U.S.C. 6924 (h)(2)).

If EPA fails to set treatment standards by the statutory deadline for any hazardous waste in the First Third or Second Third waste groups (see Section 1.1.2), the waste may not be disposed in a landfill or surface impoundment unless the facility is in compliance with the minimum technological requirements specified in section 3004(o) of RCRA. In addition, prior to disposal, the generator must certify to the Administrator that the availability of treatment capacity has been investigated, and it has been determined that disposal in a landfill or surface impoundment is the only practical alternative to treatment currently available to the generator. This restriction on the use of landfills and surface impoundments applies until EPA sets treatment standards for the waste or until May 8, 1990, whichever is sooner. If the Agency fails to set treatment standards for any ranked hazardous waste by May 8, 1990, the waste is automatically prohibited from land disposal unless the waste is placed in a land disposal unit that is the subject of a successful "no migration" demonstration (RCRA section 3004(g), 42 U.S.C. 6924(g)). "No migration" demonstrations are based on case-specific petitions that show there will be no migration of hazardous constituents from the unit for as long as the waste remains hazardous.

1.1.2 Schedule for Developing Restrictions

Under section 3004(g) of RCRA, EPA was required to establish a schedule for developing treatment standards for all wastes that the Agency had listed as hazardous by November 8, 1984. Section 3004(g) required that this schedule consider the intrinsic hazards and volumes associated with each of these wastes. The statute required EPA to set treatment standards according to the following schedule:

1. Solvent and dioxin wastes by November 8, 1986;
2. The "California List" wastes by July 8, 1987;
3. At least one-third of all listed hazardous wastes by August 8, 1988 (First Third);

4. At least two-thirds of all listed hazardous wastes by June 8, 1989 (Second Third); and

5. All remaining listed hazardous wastes and all hazardous wastes identified as of November 8, 1984, by one or more of the characteristics defined in 40 CFR Part 261 by May 8, 1990 (Third Third).

The statute specifically identified the solvent wastes as those covered under waste codes F001, F002, F003, F004, and F005; it identified the dioxin-containing hazardous wastes as those covered under waste codes F020, F021, F022, and F023.

Wastes collectively known as the California List wastes, defined under section 3004(d) of HSWA, are liquid hazardous wastes containing metals, free cyanides, PCBs, corrosives (i.e., a pH less than or equal to 2.0), and any liquid or nonliquid hazardous waste containing halogenated organic compounds (HOCs) above 0.1 percent by weight. Rules for the California List were proposed on December 11, 1986, and final rules for PCBs, corrosives, and HOC-containing wastes were established August 12, 1987. In that rule, EPA elected not to establish treatment standards for metals. Therefore, the statutory limits became effective.

On May 28, 1986, EPA published a final rule (51 FR 19300) that delineated the specific waste codes that would be addressed by the First Third, Second Third, and Third Third land disposal restriction rules. This schedule is incorporated into 40 CFR 268.10, 268.11, and 268.12.

1.2 Summary of Promulgated BDAT Methodology

In a November 7, 1986, rulemaking, EPA promulgated a technology-based approach to establishing treatment standards under section 3004(m).

Congress indicated in the legislative history accompanying the HSWA that "[t]he requisite levels of [sic] methods of treatment established by the Agency should be the best that has been demonstrated to be achievable," noting that the intent is "to require utilization of available technology" and not a "process which contemplates technology-forcing standards" (Vol. 130 Cong. Rec. S9178 (daily ed., July 25, 1984)). EPA has interpreted this legislative history as suggesting that Congress considered the requirement under section 3004(m) to be met by application of the best demonstrated and achievable (i.e., available) technology prior to land disposal of wastes or treatment residuals. Accordingly, EPA's treatment standards are generally based on the performance of the best demonstrated available technology (BDAT) identified for treatment of the hazardous constituents. This approach involves the identification of potential treatment systems, the determination of whether they are demonstrated and available, and the collection of treatment data from well-designed and well-operated systems.

The treatment standards, according to the statute, can represent levels or methods of treatment, if any, that substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents. Wherever possible, the Agency prefers to establish BDAT treatment standards as "levels" of treatment (i.e., performance standards), rather than to require the use of specific treatment "methods." EPA believes that concentration-based treatment levels offer the regulated community greater flexibility to develop and implement compliance strategies, as well as an incentive to develop innovative technologies.

1.2.1 Waste Treatability Group

In developing the treatment standards, EPA first characterizes the waste(s). As necessary, EPA may establish treatability groups for wastes having similar physical and chemical properties. That is, if EPA believes that hazardous constituents in wastes represented by different waste codes could be treated to similar concentrations using identical technologies, the Agency combines the wastes into one treatability group. EPA generally considers wastes to be similar when they are both generated from the same industry and from similar processing stages. In addition, EPA may combine two or more separate wastes into the same treatability group when data are available showing that the waste characteristics affecting performance are similar or that one of the wastes in the group, the waste from which treatment standards are to be developed, is expected to be most difficult to treat.

Once the treatability groups have been established, EPA collects and analyzes data on identified technologies used to treat the wastes in each treatability group. The technologies evaluated must be demonstrated on the waste or a similar waste and must be available for use.

1.2.2 Demonstrated and Available Treatment Technologies

Consistent with legislative history, EPA considers demonstrated technologies to be those that are currently used on a full-scale basis to treat the waste of interest or a waste judged to be similar (see 51 FR 40588, November 7, 1986). EPA also will consider as demonstrated treatment those technologies used to separate or otherwise process chemicals and other materials on a full-scale basis. Some of these technologies clearly are applicable to waste treatment, since the wastes are similar to raw materials processed in industrial applications.

For most of the waste treatability groups for which EPA will promulgate treatment standards, EPA will identify demonstrated technologies either through review of literature related to current waste treatment practices or on the basis of information provided by specific facilities currently treating the waste or similar wastes.

In cases where the Agency does not identify any facilities treating wastes represented by a particular waste treatability group, EPA may transfer a finding of demonstrated treatment. To do this, EPA will compare the parameters affecting treatment selection for the waste treatability group of interest to other wastes for which demonstrated technologies already have been determined. (The parameters affecting treatment selection and their use for this waste are described in Section 3.2 of this document.) If the parameters affecting treatment selection are similar, then the Agency will consider the treatment technology also to be demonstrated for the waste of interest. For example, EPA considers rotary kiln incineration to be a demonstrated technology for many waste codes containing hazardous organic constituents, high total organic content, and high filterable solids content, regardless of whether any facility is currently treating these wastes. The basis for this determination is data found in literature and data generated by EPA confirming the use of rotary kiln incineration on wastes having the above characteristics.

If no full-scale treatment or recovery operations are identified for a waste or wastes with similar physical or chemical characteristics that affect treatment selection, the Agency will be unable to identify any demonstrated treatment technologies for the waste, and, accordingly, the waste will be prohibited from land disposal (unless handled in accordance with the exemption and variance provisions of the rule). The Agency is, however, committed to establishing treatment standards as soon as new or improved treatment processes are demonstrated (and available).

Operations only available at research facilities, pilot- and bench-scale operations, will not be considered in identifying demonstrated treatment technologies for a waste. Nevertheless, EPA may use data generated at research facilities in assessing the performance of demonstrated technologies.

As discussed earlier, Congress intended that technologies used to establish treatment standards under section 3004(m) be not only "demonstrated," but also "available." To decide whether demonstrated technologies may be considered "available," the Agency determines whether they (1) are commercially available and (2) substantially diminish the toxicity of the waste or substantially reduce the likelihood of migration of hazardous constituents from the waste. These criteria are discussed below.

1. Commercially available treatment. If the demonstrated treatment technology is a proprietary or patented process that is not generally available, EPA will not consider the technology in its determination of the treatment standards. EPA will consider proprietary or patented processes available if it determines that the treatment method can be purchased or licensed from the proprietor or is a commercially available treatment. The services of the commercial facility offering this technology often can be purchased even if the technology itself cannot be purchased.

2. Substantial treatment. To be considered "available," a demonstrated treatment technology must "substantially diminish the toxicity" of the waste or "substantially reduce the likelihood of migration of hazardous constituents" from the waste in accordance with section 3004(m). By requiring that substantial treatment be achieved in order to set a treatment standard, the statute ensures that all wastes are adequately treated before being placed in or on the land and ensures that the Agency does not require a treatment method that provides little or no environmental benefit. Treatment will always be deemed substantial if it results in nondetectable levels of the hazardous constituents of concern (provided the nondetectable levels are low relative to the concentrations in the untreated waste). If nondetectable levels are not achieved, then a determination of substantial treatment will be made on a case-by-case basis. This approach is necessary because of the difficulty of establishing a meaningful guideline that can be applied broadly to the many wastes and technologies to be considered. EPA will consider the following factors in an effort to evaluate whether a technology provides substantial treatment on a case-by-case basis:

   - Number and types of constituents treated;

   - Performance (concentration of the constituents in the treatment residuals); and

   - Percent of constituents removed.

EPA will only set treatment standards based on a technology that meets both availability criteria. Thus, the decision to classify a technology as "unavailable" will have a direct impact on the treatment standard. If the best demonstrated technology is unavailable, the treatment standards will be based on the next best demonstrated treatment technology determined to be available. To the extent that the resulting treatment standards are less stringent, greater concentrations of hazardous constituents in the treatment residuals could be placed in land disposal units.

There also may be circumstances in which EPA concludes that for a given waste none of the demonstrated treatment technologies are "available" for purposes of establishing the 3004(m) treatment performance standards. Subsequently, these wastes will be prohibited from continued placement in or on the land unless managed in accordance with applicable exemptions and variance provisions. The Agency is, however, committed to establishing new treatment standards as soon as new or improved treatment processes become available.

1.2.3 Collection of Performance Data

Performance data on the demonstrated available technologies are evaluated by the Agency to determine whether the data are representative of well-designed and well-operated treatment systems. Only data from well-designed and well-operated systems are considered in determining BDAT. The data evaluation includes data already collected directly by

EPA and/or data provided by industry. In those instances where additional data are needed to supplement existing information, EPA collects additional data through a sampling and analysis program. The principal elements of this data collection program are: (1) the identification of facilities for site visits, (2) the engineering site visit, (3) the sampling and analysis plan, (4) the sampling visit, and (5) the onsite engineering report.

(1) Identification of facilities for site visits. To identify facilities that generate and/or treat the waste of concern, EPA uses a number of information sources. These include Stanford Research Institute's Directory of Chemical Producers; EPA's Hazardous Waste Data Management System (HWDMS); the 1986 Treatment, Storage, Disposal Facility (TSDF) National Screening Survey; and EPA's Industry Studies Data Base. In addition, EPA contacts trade associations to inform them that the Agency is considering visits to facilities in their industry and to solicit their assistance in identifying facilities for EPA to consider in its treatment sampling program.

After identifying facilities that treat the waste, EPA uses this hierarchy to select sites for engineering visits: (1) generators treating single wastes on site; (2) generators treating multiple wastes together on site; (3) commercial treatment, storage, and disposal facilities (TSDFs); and (4) EPA in-house treatment. This hierarchy is based on two concepts: (1) to the extent possible, EPA should develop treatment standards from data produced by treatment facilities handling only a single waste, and (2) facilities that routinely treat a specific waste have had the best opportunity to optimize design parameters. Although excellent treatment can occur at many facilities that are not high in this hierarchy, EPA has adopted this approach to avoid, when possible, ambiguities related to the mixing of wastes before and during treatment.

When possible, the Agency will evaluate treatment technologies using full-scale treatment systems. If performance data from properly designed and operated full-scale systems treating a particular waste or a waste judged to be similar are not available, EPA may use data from research facility operations. Whenever research facility data are used, EPA will explain in the preamble and background document why such data were used and will request comments on the use of such data.

Although EPA's data bases provide information on treatment for individual wastes, the data bases rarely provide data that support the selection of one facility for sampling over another. In cases where several treatment sites appear to fall into the same level of the hierarchy, EPA selects sites for visits strictly on the basis of which facility could most expeditiously be visited and later sampled if justified by the engineering visit.

(2) Engineering site visit. Once a treatment facility has been selected, an engineering site visit is made to confirm that a candidate for sampling meets EPA's criteria for a well-designed facility and to

ensure that the necessary sampling points can be accessed to determine operating parameters and treatment effectiveness. During the visit, EPA also confirms that the facility appears to be well operated, although the actual operation of the treatment system during sampling is the basis for EPA's decisions regarding proper operation of the treatment unit. In general, the Agency considers a well-designed facility to be one that contains the unit operations necessary to treat the various hazardous constituents of the waste, as well as to control other nonhazardous materials in the waste that may affect treatment performance.

In addition to ensuring that a system is reasonably well designed, the engineering visit examines whether the facility has a way to measure the operating parameters that affect performance of the treatment system during the waste treatment period. For example, EPA may choose not to sample a treatment system that operates in a continuous mode, for which an important operating parameter cannot be continuously recorded. In such systems, instrumentation is important in determining whether the treatment system is operating at design values during the waste treatment period.

(3) Sampling and analysis plan. If after the engineering site visit the Agency decides to sample a particular plant, the Agency will then develop a site-specific sampling and analysis plan (SAP) according to the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011. In brief, the SAP discusses where the Agency plans to sample, how the samples will be taken, the frequency

of sampling, the constituents to be analyzed and the method of analysis, operational parameters to be obtained, and specific laboratory quality control checks on the analytical results.

The Agency will generally produce a draft of the site-specific SAP within 2 to 3 weeks of the engineering visit. The draft of the SAP is then sent to the plant for review and comment. With few exceptions, the draft SAP should be a confirmation of data collection activities discussed with the plant personnel during the engineering site visit. EPA encourages plant personnel to recommend any modifications to the SAP that they believe will improve the quality of the data.

It is important to note that sampling of a plant by EPA does not mean that the data will be used in the development of BDAT treatment standards. EPA's final decision on whether to use data from a sampled plant depends on the actual analysis of the waste being treated and on the operating conditions at the time of sampling. Although EPA would not plan to sample a facility that was not ostensibly well designed and well operated, there is no way to ensure that at the time of the sampling the facility will not experience operating problems. Additionally, EPA statistically compares its test data to suitable industry-provided data, where available, in its determination of what data to use in developing treatment standards. The methodology for comparing data is presented later in this section.

(Note: Facilities wishing to submit data for consideration in the development of BDAT standards should, to the extent possible, provide sampling information similar to that acquired by EPA. Such facilities should review the Generic Quality Assurance Project Plan for the Land Disposal Restrictions Program ("BDAT"), which delineates all of the quality control and quality assurance measures associated with sampling and analysis. Quality assurance and quality control procedures are summarized in Section 1.2.6 of this document.)

(4) Sampling visit. The purpose of the sampling visit is to collect samples that characterize the performance of the treatment system and to document the operating conditions that existed during the waste treatment period. At a minimum, the Agency attempts to collect sufficient samples of the untreated waste and solid and liquid treatment residuals so that variability in the treatment process can be accounted for in the development of the treatment standards. To the extent practicable, and within safety constraints, EPA or its contractors collect all samples and ensure that chain-of-custody procedures are conducted so that the integrity of the data is maintained.

In general, the samples collected during the sampling visit will have already been specified in the SAP. In some instances, however, EPA will not be able to collect all planned samples because of changes in the facility operation or plant upsets; EPA will explain any such deviations from the SAP in its follow-up onsite engineering report.

(5) Onsite engineering report. EPA summarizes all its data collection activities and associated analytical results for testing at a facility in a report referred to as the onsite engineering report (OER). This report characterizes the waste(s) treated, the treated residual concentrations, the design and operating data, and all analytical results including methods used and accuracy results. This report also describes any deviations from EPA's suggested analytical methods for hazardous wastes that appear in Test Methods for Evaluating Solid Waste, SW-846, Third Edition, November 1986.

After the OER is completed, the report is submitted to the waste generator and/or treater for review. This review provides a final opportunity for claiming any information contained in the report as confidential. Following the review and incorporation of comments, as appropriate, the report is made available to the public with the exception of any material claimed as confidential.

1.2.4 Hazardous Constituents Considered and Selected for Regulation

(1) Development of BDAT list. The list of hazardous constituents within the waste codes that are targeted for treatment is referred to by the Agency as the BDAT constituent list. This list, provided as Table 1-1, is derived from the constituents presented in 40 CFR Part 261, Appendices VII and VIII, as well as several ignitable constituents used as the basis of listing wastes as F003 and F005. These sources provide a

Table 1-1 BDAT Constituent List

BDAT reference no.	Constituent	CAS no.
	Volatile organics	
222.	Acetone	67-64-1
1.	Acetonitrile	75-05-8
2.	Acrolein	107-02-8
3.	Acrylonitrile	107-13-1
4.	Benzene	71-43-2
5.	Bromodichloromethane	75-27-4
6.	Bromomethane	74-83-9
223.	n-Butyl alcohol	71-36-3
7.	Carbon tetrachloride	56-23-5
8.	Carbon disulfide	75-15-0
9.	Chlorobenzene	108-90-7
10.	2-Chloro-1,3-butadiene	126-99-8
11.	Chlorodibromomethane	124-48-1
12.	Chloroethane	75-00-3
13.	2-Chloroethyl vinyl ether	110 75 8
14.	Chloroform	67-66-3
15.	Chloromethane	74-87-3
16.	3-Chloropropene	107-05-1
17.	1,2-Dibromo-3-chloropropane	96-12-8
18.	1,2-Dibromoethane	106-93-4
19.	Dibromomethane	74-95-3
20.	trans-1,4-Dichloro-2-butene	110-57-6
21.	Dichlorodifluoromethane	75-71-8
22.	1,1-Dichloroethane	75-34-3
23.	1,2-Dichloroethane	107-06-2
24.	1,1-Dichloroethylene	75-35-4
25.	trans-1,2-Dichloroethene	156-60-5
26.	1,2-Dichloropropane	78-87-5
27.	trans-1,3-Dichloropropene	10061-02-6
28.	cis-1,3-Dichloropropene	10061-01-5
29.	1,4-Dioxane	123-91-1
224.	2-Ethoxyethanol	110-80-5
225.	Ethyl acetate	141-78-6
226.	Ethyl benzene	100-41-4
30.	Ethyl cyanide	107-12-0
227.	Ethyl ether	60-29-7
31.	Ethyl methacrylate	97-63-2
214.	Ethylene oxide	75-21-8
32.	Iodomethane	74 88 4
33.	Isobutyl alcohol	78-83-1
228.	Methanol	67-56-1
34.	Methyl ethyl ketone	78 93-3

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Volatile organics (continued)	
229.	Methyl isobutyl ketone	108-10-1
35.	Methyl methacrylate	80-62-6
37.	Methacrylonitrile	126-98-7
38.	Methylene chloride	75-09-2
230.	2-Nitropropane	79-46-9
39.	Pyridine	110-86-1
40.	1,1,1,2-Tetrachloroethane	630-20-6
41.	1,1,2,2-Tetrachloroethane	79-34-6
42.	Tetrachloroethene	127-18-4
43.	Toluene	108-88-3
44.	Tribromomethane	75-25-2
45.	1,1,1-Trichloroethane	71-55-6
46.	1,1,2-Trichloroethane	79-00-5
47.	Trichloroethene	79-01-6
48.	Trichloromonofluoromethane	75-69-4
49.	1,2,3-Trichloropropane	96-18-4
231.	1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
50.	Vinyl chloride	75-01-4
215.	1,2-Xylene	97-47-6
216.	1,3-Xylene	108-38-3
217.	1,4-Xylene	106-44-5
	Semivolatile organics	
51.	Acenaphthalene	208-96-8
52.	Acenaphthene	83-32-9
53.	Acetophenone	96-86-2
54.	2-Acetylaminofluorene	53-96-3
55.	4-Aminobiphenyl	92-67-1
56.	Aniline	62-53-3
57.	Anthracene	120-12-7
58.	Aramite	140-57-8
59.	Benz(a)anthracene	56-55-3
218.	Benzal chloride	98-87-3
60.	Benzenethiol	108-98-5
61.	Deleted	
62.	Benzo(a)pyrene	50-32-8
63.	Benzo(b)fluoranthene	205-99-2
64.	Benzo(ghi)perylene	191-24-2
65.	Benzo(k)fluoranthene	207-08-9
66.	p-Benzoquinone	106-51-4

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
67.	Bis(2-chloroethoxy)methane	111-91-1
68.	Bis(2-chloroethyl)ether	111-44-4
69.	Bis(2-chloroisopropyl)ether	39638-32-9
70.	Bis(2-ethylhexyl)phthalate	117-81-7
71.	4-Bromophenyl phenyl ether	101-55-3
72.	Butyl benzyl phthalate	85-68-7
73.	2-sec-Butyl-4,6-dinitrophenol	88-85-7
74.	p-Chloroaniline	106-47-8
75.	Chlorobenzilate	510-15-6
76.	p-Chloro-m-cresol	59-50-7
77.	2-Chloronaphthalene	91-58-7
78.	2-Chlorophenol	95-57-8
79.	3-Chloropropionitrile	542-76-7
80.	Chrysene	218-01-9
81.	ortho-Cresol	95-48-7
82.	para-Cresol	106-44-5
232.	Cyclohexanone	108-94-1
83.	Dibenz(a,h)anthracene	53-70-3
84.	Dibenzo(a,e)pyrene	192-65-4
85.	Dibenzo(a,i)pyrene	189-55-9
86.	m-Dichlorobenzene	541-73-1
87.	o-Dichlorobenzene	95-50-1
88.	p-Dichlorobenzene	106-46-7
89.	3,3'-Dichlorobenzidine	91-94-1
90.	2,4-Dichlorophenol	120-83-2
91.	2,6-Dichlorophenol	87-65-0
92.	Diethyl phthalate	84-66-2
93.	3,3'-Dimethoxybenzidine	119-90-4
94.	p-Dimethylaminoazobenzene	60-11-7
95.	3,3'-Dimethylbenzidine	119-93-7
96.	2,4-Dimethylphenol	105-67-9
97.	Dimethyl phthalate	131-11-3
98.	Di-n-butyl phthalate	84-74-2
99.	1,4-Dinitrobenzene	100-25-4
100.	4,6-Dinitro-o-cresol	534-52-1
101.	2,4-Dinitrophenol	51-28-5
102.	2,4-Dinitrotoluene	121-14-2
103.	2,6-Dinitrotoluene	606-20-2
104.	Di-n-octyl phthalate	117-84-0
105.	Di-n-propylnitrosamine	621-64-7
106.	Diphenylamine	122-39-4
219.	Diphenylnitrosamine	86-30-6

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
107.	1,2-Diphenylhydrazine	122-66-7
108.	Fluoranthene	206-44-0
109.	Fluorene	86-73-7
110.	Hexachlorobenzene	118-74-1
111.	Hexachlorobutadiene	87-68-3
112.	Hexachlorocyclopentadiene	77-47-4
113.	Hexachloroethane	67-72-1
114.	Hexachlorophene	70-30-4
115.	Hexachloropropene	1888-71-7
116.	Indeno(1,2,3-cd)pyrene	193-39-5
117.	Isosafrole	120-58-1
118.	Methapyrilene	91-80-5
119.	3-Methylcholanthrene	56-49-5
120.	4,4'-Methylenebis (2-chloroaniline)	101-14-4
36.	Methyl methanesulfonate	66-27-3
121.	Naphthalene	91-20-3
122.	1,4-Naphthoquinone	130-15-4
123.	1-Naphthylamine	134-32-7
124.	2-Naphthylamine	91-59-8
125.	p-Nitroaniline	100-01-6
126.	Nitrobenzene	98-95-3
127.	4-Nitrophenol	100-02-7
128.	N-Nitrosodi-n-butylamine	924-16-3
129.	N-Nitrosodiethylamine	55-18-5
130.	N-Nitrosodimethylamine	62-75-9
131.	N-Nitrosomethylethylamine	10595-95-6
132.	N-Nitrosomorpholine	59-89-2
133.	N-Nitrosopiperidine	100-75-4
134.	N-Nitrosopyrrolidine	930-55-2
135.	5-Nitro-o-toluidine	99-65-8
136.	Pentachlorobenzene	608-93-5
137.	Pentachloroethane	76-01-7
138.	Pentachloronitrobenzene	82-68-8
139.	Pentachlorophenol	87-86-5
140.	Phenacetin	62-44-2
141.	Phenanthrene	85-01-8
142.	Phenol	108-95-2
220.	Phthalic anhydride	85-44-9
143.	2-Picoline	109-06-8
144.	Pronamide	23950-58-5
145.	Pyrene	129-00-0
146.	Resorcinol	108-46-3

Table 1 1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Semivolatile organics (continued)	
147.	Safrole	94-59-7
148.	1,2,4,5-Tetrachlorobenzene	95-94-3
149.	2,3,4,6-Tetrachlorophenol	58-90-2
150.	1,2,4-Trichlorobenzene	120-82-1
151.	2,4,5-Trichlorophenol	95-95-4
152.	2,4,6-Trichlorophenol	88-06-2
153.	Tris(2,3-dibromopropyl) phosphate	126-72-7
	Metals	
154.	Antimony	7440-36-0
155.	Arsenic	7440-38-2
156.	Barium	7440-39-3
157.	Beryllium	7440-41-7
158.	Cadmium	7440-43-9
159.	Chromium (total)	7440-47-3
221.	Chromium (hexavalent)	-
160.	Copper	7440-50-8
161.	Lead	7439-92-1
162.	Mercury	7439-97-6
163.	Nickel	7440-02-0
164.	Selenium	7782-49-2
165.	Silver	7440-22-4
166.	Thallium	7440-28-0
167.	Vanadium	7440-62-2
168.	Zinc	7440-66-6
	Inorganics other than metals	
169.	Cyanide	57-12-5
170.	Fluoride	16964-48-8
171.	Sulfide	8496-25-8
	Organochlorine pesticides	
172.	Aldrin	309-00-2
173.	alpha-BHC	319-84-6
174.	beta-BHC	319-85-7
175.	delta-BHC	319-86-8

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Organochlorine pesticides (continued)	
176.	gamma-BHC	58-89-9
177.	Chlordane	57-74-9
178.	DDD	72-54-8
179.	DDE	72-55-9
180.	DDT	50-29-3
181.	Dieldrin	60-57-1
182.	Endosulfan I	939-98-8
183.	Endosulfan II	33213-6-5
184.	Endrin	72-20-8
185.	Endrin aldehyde	7421-93-4
186.	Heptachlor	76-44-8
187.	Heptachlor epoxide	1024-57-3
188.	Isodrin	465-73-6
189.	Kepone	143-50-0
190.	Methoxyclor	72-43-5
191.	Toxaphene	8001-35-2
	Phenoxyacetic acid herbicides	
192.	2,4-Dichlorophenoxyacetic acid	94-75-7
193.	Silvex	93-72-1
194.	2,4,5-T	93-76-5
	Organophosphorous insecticides	
195.	Disulfoton	298-04-4
196.	Famphur	52-85-7
197.	Methyl parathion	298-00-0
198.	Parathion	56-38-2
199.	Phorate	298-02-2
	PCBs	
200.	Aroclor 1016	12674-11-2
201.	Aroclor 1221	11104-28-2
202.	Aroclor 1232	11141-16-5
203.	Aroclor 1242	53469-21-9
204.	Aroclor 1248	12672-29-6
205.	Aroclor 1254	11097-69-1
206.	Aroclor 1260	11096-82-5

Table 1-1 (Continued)

BDAT reference no.	Constituent	CAS no.
	Dioxins and furans	
207.	Hexachlorodibenzo-p-dioxins	-
208.	Hexachlorodibenzofurans	-
209.	Pentachlorodibenzo-p-dioxins	-
210.	Pentachlorodibenzofurans	-
211.	Tetrachlorodibenzo-p-dioxins	-
212.	Tetrachlorodibenzofurans	-
213.	2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6

comprehensive list of hazardous constituents specifically regulated under RCRA. The BDAT list consists of those constituents that can be analyzed using methods published in SW-846, Third Edition.

The initial BDAT constituent list was published in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") in March 1987. Additional constituents are added to the BDAT constituent list as more key constituents are identified for specific waste codes or as new analytical methods are developed for hazardous constituents. For example, since the list was published in March 1987, 18 additional constituents (hexavalent chromium, xylenes (all three isomers), benzal chloride, phthalic anhydride, ethylene oxide, acetone, n-butyl alcohol, 2-ethoxyethanol, ethyl acetate, ethyl benzene, ethyl ether, methanol, methyl isobutyl ketone, 2-nitropropane, 1,1,2-trichloro-1,2,2-trifluoroethane, and cyclohexanone) have been added to the list.

Chemicals are listed in Appendix VIII if they are shown in scientific studies to have toxic, carcinogenic, mutagenic, or teratogenic effects on humans or other life-forms, and they include such substances as those identified by the Agency's Carcinogen Assessment Group as being carcinogenic. A waste can be listed as a toxic waste on the basis that it contains a constituent in Appendix VIII.

Although Appendix VII, Appendix VIII, and the F003 and F005 ignitables provide a comprehensive list of RCRA-regulated hazardous constituents, not all of the constituents can be analyzed in a complex waste matrix. Therefore, constituents that could not be readily analyzed in an unknown waste matrix were not included on the initial BDAT constituent list. As mentioned above, however, the BDAT constituent list is a continuously growing list that does not preclude the addition of new constituents when analytical methods are developed.

There are five major reasons that constituents were not included on the BDAT constituent list:

1. Constituents are unstable. Based on their chemical structure, some constituents will either decompose in water or will ionize. For example, maleic anhydride will form maleic acid when it comes in contact with water, and copper cyanide will ionize to form copper and cyanide ions. However, EPA may choose to regulate the decomposition or ionization products.

2. EPA-approved or verified analytical methods are not available. Many constituents, such as 1,3,5-trinitrobenzene, are not measured adequately or even detected using any of EPA's analytical methods published in SW-846 Third Edition.

3. The constituent is a member of a chemical group designated in Appendix VIII as not otherwise specified (N.O.S.). Constituents listed as N.O.S., such as chlorinated phenols, are a generic group of some types of chemicals for which a single analytical procedure is not available. The individual members of each such group need to be listed to determine whether the constituents can be analyzed. For each N.O.S. group, all those constituents that can be readily analyzed are included in the BDAT constituent list.

4. Available analytical procedures are not appropriate for a complex waste matrix. Some compounds, such as auramine, can be analyzed as a pure constituent. However, in the presence of other constituents, the recommended analytical method does not positively identify the constituent. The use of high performance liquid chromatography (HPLC) presupposes a high expectation of finding the specific constituents of interest. In using this procedure to screen samples, protocols would have to be developed on a case-specific basis to verify the identity of constituents present in the samples. Therefore, HPLC is usually not an appropriate analytical procedure for complex samples containing unknown constituents.

5. Standards for analytical instrument calibration are not commercially available. For several constituents, such as benz(c)acridine, commercially available standards of a "reasonably" pure grade are not available. The unavailability of a standard was determined by a review of catalogs from specialty chemical manufacturers.

Two constituents (fluoride and sulfide) are not specifically included in Appendices VII and VIII; however, these compounds are included on the BDAT list as indicator constituents for compounds from Appendices VII and VIII such as hydrogen fluoride and hydrogen sulfide, which ionize in water.

The BDAT constituent list presented in Table 1-1 is divided into the following nine groups:

- Volatile organics;
- Semivolatile organics;
- Metals;
- Other inorganics;
- Organochlorine pesticides;
- Phenoxyacetic acid herbicides;
- Organophosphorous insecticides;
- PCBs; and
- Dioxins and furans.

The constituents were placed in these categories based on their chemical properties. The constituents in each group are expected to behave similarly during treatment and are also analyzed, with the exception of the metals and the other inorganics, by using the same analytical methods.

(2) Constituent selection analysis. The constituents that the Agency selects for regulation in each waste are, in general, those found in the untreated wastes at treatable concentrations. For certain waste

codes, the target list for the untreated waste may have been shortened (relative to analyses performed to test treatment technologies) because of the extreme unlikelihood that the constituent will be present.

In selecting constituents for regulation, the first step is to develop of list of potentially regulated constituents by summarizing all the constituents that are present or are likely to be present in the untreated waste at treatable concentrations. A constituent is considered present in a waste if the constituent (1) is detected in the untreated waste above the detection limit, (2) is detected in any of the treated residuals above the detection limit, or (3) is likely to be present based on the Agency's analyses of the waste-generating process. In case (2), the presence of other constituents in the untreated waste may interfere with the quantification of the constituent of concern, making the detection limit relatively high and resulting in a finding of "not detected" when, in fact, the constituent is present in the waste. Thus, the Agency reserves the right to regulate such constituents.

After developing a list of potential constituents for regulation. EPA reviews this list to determine if any of these constituents can be excluded from regulation because they would be controlled by regulation of other constituents on the list. This indicator analysis is done for two reasons: (1) it reduces the analytical cost burdens on the treater and (2) it facilitates implementation of the compliance and enforcement program. EPA's rationale for selection of regulated constituents for this waste code is presented in Section 6 of this background document.

(3) Calculation of standards. The final step in the calculation of the BDAT treatment standard is the multiplication of the average accuracy-corrected treatment value by a factor referred to by the Agency as the variability factor. This calculation takes into account that even well-designed and well-operated treatment systems will experience some fluctuations in performance. EPA expects that fluctuations will result from inherent mechanical limitations in treatment control systems, collection of treated samples, and analysis of these samples. All of the above fluctuations can be expected to occur at well-designed and well-operated treatment facilities. Therefore, setting treatment standards utilizing a variability factor should be viewed not as a relaxing of section 3004(m) requirements, but rather as a function of the normal variability of the treatment processes. A treatment facility will have to be designed to meet the mean achievable treatment performance level to ensure that the performance levels remain within the limits of the treatment standard.

The Agency calculates a variability factor for each constituent of concern within a waste treatability group using the statistical calculation presented in Appendix A. The equation for calculating the variability factor is the same as that used by EPA for the development of numerous regulations in the Effluent Guidelines Program under the Clean Water Act. The variability factor establishes the instantaneous maximum based on the 99th percentile value.

There is an additional step in the calculation of the treatment standards in those instances where the ANOVA analysis shows that more than one technology achieves a level of performance that represents BDAT. In such instances, the BDAT treatment standard for each constituent of concern is calculated by first averaging the mean performance value for each technology and then multiplying that value by the highest variability factor among the technologies considered. This procedure ensures that all the technologies used as the basis for the BDAT treatment standards will achieve full compliance.

1.2.5 Compliance with Performance Standards

Usually the treatment standards reflect performance achieved by the best demonstrated available technology (BDAT). As such, compliance with these numerical standards requires only that the treatment level be achieved prior to land disposal. It does not require the use of any particular treatment technology. While dilution of the waste as a means to comply with the standards is prohibited, wastes that are generated in such a way as to naturally meet the standards can be land disposed without treatment. With the exception of treatment standards that prohibit land disposal or that specify use of certain treatment methods, all established treatment standards are expressed as concentration levels.

EPA is using both the total constituent concentration and the concentration of the constituent in the TCLP extract of the treated waste as a measure of technology performance.

For all organic constituents, EPA is basing the treatment standards on the total constituent concentration found in the treated waste. EPA is using this measurement because most technologies for treatment of organics destroy or remove organics compounds. Accordingly, the best measure of performance would be the total amount of constituent remaining after treatment. (NOTE: EPA's land disposal restrictions for solvent waste codes F001-F005 (51 FR 40572) use the TCLP extract value as a measure of performance. At the time that EPA promulgated the treatment standards for F001-F005, useful data were not available on total constituent concentrations in treated residuals, and, as a result, the TCLP data were considered to be the best measure of performance.)

For all metal constituents, EPA is using both total constituent concentration and/or the TCLP extract concentration as the basis for treatment standards. The total constituent concentration is being used when the technology basis includes a metal recovery operation. The underlying principle of metal recovery is that it reduces the amount of metal in a waste by separating the metal for recovery; total constituent concentration in the treated residual, therefore, is an important measure of performance for this technology. Additionally, EPA also believes that it is important that any remaining metal in a treated residual waste not be in a state that is easily leachable; accordingly, EPA is also using the TCLP extract concentration as a measure of performance. It is important to note that for wastes for which treatment standards are based on a metal recovery process, the facility has to comply with both the total and the TCLP extract constituent concentrations prior to land disposing the waste.

In cases where treatment standards for metals are not based on recovery techniques but rather on stabilization, EPA is using only the TCLP value as a measure of performance. The Agency's rationale is that stabilization is not meant to reduce the concentration of metal in a waste but only to chemically minimize the ability of the metal to leach.

1.2.6 Identification of BDAT

BDAT for a waste must be the "best" of the demonstrated available technologies. EPA determines which technology constitutes "best" after screening the available data from each demonstrated technology, adjusting these data for accuracy, and comparing the performance of each demonstrated technology to that of the others. If only one technology is identified as demonstrated, it is considered "best"; if it is available, the technology is BDAT.

(1) Screening of treatment data. The first activity in determining which of the treatment technologies represent treatment by BDAT is to screen the treatment performance data from each of the demonstrated and available technologies according to the following criteria:

1. Design and operating data associated with the treatment data must reflect a well-designed, well-operated system for each treatment data point. (The specific design and operating parameters for each demonstrated technology for the waste code(s) of interest are discussed in Section 3.2 of this document.)

2. Sufficient QA/QC data must be available to determine the true values of the data from the treated waste. This screening criterion involves adjustment of treated data to take into account that the true value may be different from the measured value. This discrepancy generally is caused by other constituents in the waste that can mask results or otherwise interfere with the analysis of the constituent of concern.

3. The measure of performance must be consistent with EPA's approach to evaluating treatment by type of constituents (e.g., total concentration data for organics, and total concentration and TCLP extract concentration for metals from the residual).

In the absence of data needed to perform the screening analysis, EPA will make decisions on a case-by-case basis as to whether to use the data as a basis for the treatment standards. The factors included in this case-by-case analysis will be the actual treatment levels achieved, the availability of the treatment data and their completeness (with respect to the above criteria), and EPA's assessment of whether the untreated waste represents the waste code of concern.

(2) Comparison of treatment data. In cases in which EPA has treatment data from more than one demonstrated available technology following the screening activity, EPA uses the statistical method known as analysis of variance (ANOVA) to determine if one technology performs significantly better than the others. This statistical method (summarized in Appendix A) provides a measure of the differences between two data sets. Specifically, EPA uses the analysis of variance to determine whether BDAT represents a level of performance achieved by only one technology or represents a level of performance achieved by more than one (or all) of the technologies. If EPA finds that one technology performs significantly better (i.e., is "best"), BDAT treatment standards

are the level of performance achieved by that best technology multiplied by the corresponding variability factor for each regulated constituent. If the Agency finds that the levels of performance for one or more technologies are not statistically different, EPA averages the performance values achieved by each technology and then multiplies this value by the largest variability factor associated with any of the technologies.

(3) Quality assurance/quality control. This section presents the principal quality assurance/quality control (QA/QC) procedures employed in screening and adjusting the data to be used in the calculation of treatment standards. Additional QA/QC procedures used in collecting and screening data for the BDAT program are presented in EPA's Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-87-011.

To calculate the treatment standards for the land disposal restriction rules, it is first necessary to determine the recovery value for each constituent (the amount of constituent recovered after spiking--which is the addition of a known amount of the constituent--minus the initial concentration in the samples, all divided by the spike amount added) for each spiked sample of the treated residual. Once the recovery values are determined, the following procedures are used to select the appropriate percent recovery value to adjust the analytical data:

1. If duplicate spike recovery values are available for the constituent of interest, the data are adjusted by the lowest available percent recovery value (i.e., the value that will yield the most conservative estimate of treatment achieved). However, if a spike recovery value of less than 20 percent is reported for a specific constituent, the data are not used to set treatment standards because the Agency does not have sufficient confidence in the reported value to set a national standard.

2. If data are not available for a specific constituent but are available for an isomer, then the spike recovery data are transferred from the isomer and the data are adjusted using the percent recovery selected according to the procedure described in (1) above.

3. If data are not available for a specific constituent but are available for a similar class of constituents (e.g., volatile organics, acid-extractable semivolatiles), then spike recovery data available for this class of constituents are transferred. All spike recovery values greater than or equal to 20 percent for a spike sample are averaged and the constituent concentration is adjusted by the average recovery value. If spiked recovery data are available for more than one sample, the average is calculated for each sample and the data are adjusted by using the lowest average value.

4. If matrix spike recovery data are not available for a set of data to be used to calculate treatment standards, then matrix spike recovery data are transferred from a waste that the Agency believes is similar (e.g., if the data represent an ash from incineration, then data from other incinerator ashes could be used). While EPA recognizes that transfer of matrix spike recovery data from a similar waste is not an exact analysis, this is considered the best approach for adjusting the data to account for the fact that most analyses do not result in extraction of 100 percent of the constituent. In assessing the recovery data to be transferred, the procedures outlined in (1), (2), and (3) above are followed.

The analytical procedures employed to generate the data used to calculate the treatment standards are listed in Appendix B of this document. In cases where alternatives or equivalent procedures and/or equipment are allowed in EPA's SW-846, Third Edition methods, the specific procedures and equipment used are documented. In addition, any deviations from the SW-846, Third Edition methods used to analyze the specific waste matrices are documented. It is important to note that the Agency will use the methods and procedures delineated in Appendix B to enforce the treatment standards presented in Section 7 of this document. Accordingly, facilities should use these procedures in assessing the performance of their treatment systems.

1.2.7 BDAT Treatment Standards for "Derived-From" and "Mixed" Wastes

(1) Wastes from treatment trains generating multiple residues. In a number of instances, the proposed BDAT consists of a series of operations, each of which generates a waste residue. For example, the proposed BDAT for a certain waste code is based on solvent extraction, steam stripping, and activated carbon adsorption. Each of these treatment steps generates a waste requiring treatment--a solvent-containing stream from solvent extraction, a stripper overhead, and spent activated carbon. Treatment of these wastes may generate further residues; for instance, spent activated carbon (if not regenerated) could be incinerated, generating an ash and possibly a scrubber water waste. Ultimately, additional wastes are generated that may require land disposal. With respect to these wastes, the Agency wishes to emphasize the following points:

1. All of the residues from treating the original listed wastes are likewise considered to be the listed waste by virtue of the derived-from rule contained in 40 CFR 261.3(c)(2). (This point is discussed more fully in (2) below.) Consequently, all of the wastes generated in the course of treatment would be prohibited from land disposal unless they satisfy the treatment standard or meet one of the exceptions to the prohibition.

2. The Agency's proposed treatment standards generally contain a concentration level for wastewaters and a concentration level for nonwastewaters. The treatment standards apply to all of the wastes generated in treating the original prohibited waste. Thus, all derived-from wastes meeting the Agency definition of wastewater (less than 1 percent total organic carbon (TOC) and less than 1 percent total suspended solids) would have to meet the treatment standard for wastewaters. All residuals not meeting this definition would have to meet the treatment standard for nonwastewaters. EPA wishes to make clear that this approach is not meant to allow partial treatment in order to comply with the applicable standard.

3. The Agency has not performed tests, in all cases, on every waste that can result from every part of the treatment train. However, the Agency's treatment standards are based on treatment of the most concentrated form of the waste. Consequently, the Agency believes that the less concentrated wastes generated in the course of treatment will also be able to be treated to meet this value.

(2) Mixtures and other derived-from residues. There is a further question as to the applicability of the BDAT treatment standards to residues generated not from treating the waste (as discussed above), but from other types of management. Examples are contaminated soil or leachate that is derived from managing the waste. In these cases, the mixture is still deemed to be the listed waste, either because of the derived-from rule (40 CFR 261.3(c)(2)(i)) or the mixture rule (40 CFR 261.3(a)(2)(iii) and (iv)) or because the listed waste is contained in the matrix (see, for example, 40 CFR 261.33(d)). The prohibition for the particular listed waste consequently applies to this type of waste.

The Agency believes that the majority of these types of residues can meet the treatment standards for the underlying listed wastes (with the possible exception of contaminated soil and debris for which the Agency is currently investigating whether it is appropriate to establish a separate treatability subcategorization). For the most part, these residues will be less concentrated than the original listed waste. The Agency's treatment standards also make a generous allowance for process variability by assuming that all treatability values used to establish the standard are lognormally distributed. The waste also might be amenable to a relatively nonvariable form of treatment technology such as incineration. Finally, and perhaps most important, the rules contain a treatability variance that allows a petitioner to demonstrate that its waste cannot be treated to the level specified in the rule (40 CFR Part 268.44(a)). This provision provides a safety valve that allows persons with unusual waste matrices to demonstrate the appropriateness of a different standard. The Agency, to date, has not received any petitions under this provision (for example, for residues contaminated with a prohibited solvent waste), indicating, in the Agency's view, that the existing standards are generally achievable.

(3) Residues from managing listed wastes or that contain listed wastes. The Agency has been asked if and when residues from managing hazardous wastes, such as leachate and contaminated ground water, become subject to the land disposal prohibitions. Although the Agency believes this question to be settled by existing rules and interpretative statements, to avoid any possible confusion the Agency will address the question again.

Residues from managing First Third wastes, listed California List wastes, and spent solvent and dioxin wastes are all considered to be subject to the prohibitions for the listed hazardous waste as originally generated. Residues from managing California List wastes likewise are subject to the California List prohibitions when the residues themselves exhibit a characteristic of hazardous waste. This determination stems directly from the derived-from rule in 40 CFR 261.3(c)(2) or, in some cases, from the fact that the waste is mixed with or otherwise contains the listed waste. The underlying principle stated in all of these provisions is that listed wastes remain listed until delisted.

The Agency's historic practice in processing delisting petitions that address mixing residuals has been to consider them to be the listed waste and to require that delisting petitioners address all constituents for which the derived-from waste (or other mixed waste) was listed. The language in 40 CFR 260.22(b) states that mixtures or derived-from residues can be delisted provided a delisting petitioner makes a demonstration identical to that which a delisting petitioner would make for the original listed waste. Consequently, these residues are treated as the original listed waste for delisting purposes. The statute likewise takes this position, indicating that soil and debris that are contaminated with listed spent solvents or dioxin wastes are subject to the prohibition for these wastes even though these wastes are not the originally generated waste, but rather are a residual from management (RCRA section 3004(e)(3)). It is EPA's view that all such residues are covered by the existing prohibitions and treatment standards for the listed hazardous waste that these residues contain or from which they are derived.

1.2.8 Transfer of Treatment Standards

EPA is proposing some treatment standards that are not based on testing of the treatment technology on the specific waste subject to the treatment standard. The Agency has determined that the constituents present in the untested waste can be treated to the same performance levels as those observed in other wastes for which EPA has previously developed treatment data. EPA believes that transferring treatment performance data for use in establishing treatment standards for untested wastes is technically valid in cases where the untested wastes are generated from similar industries or processing steps, or have similar waste characteristics affecting performance and treatment selection. Transfer of treatment standards to similar wastes or wastes from similar processing steps requires little formal analysis. However, in a case where only the industry is similar, EPA more closely examines the waste characteristics prior to deciding whether the untested waste constituents can be treated to levels associated with tested wastes.

EPA undertakes a two-step analysis when determining whether constituents in the untested wastes can be treated to the same level of performance as in the tested waste. First, EPA reviews the available waste characterization data to identify those parameters that are expected to affect treatment selection. EPA has identified some of the most important constituents and other parameters needed to select the treatment technology appropriate for the given waste(s) in Section 3.

Second, when analysis suggests that an untested waste can be treated with the same technology as a waste for which treatment performance data are already available, EPA analyzes a more detailed list of characteristics that the Agency believes will affect the performance of the technology. By examining and comparing these characteristics, the Agency determines whether the untested wastes will achieve the same level of treatment as the tested waste. Where the Agency determines that the untested waste can be treated as well or better than the tested waste, the treatment standards can be transferred.

1.3 Variance from the BDAT Treatment Standard

The Agency recognizes that there may exist unique wastes that cannot be treated to the level specified as the treatment standard. In such a case, a generator or owner/operator may submit a petition to the Administrator requesting a variance from the treatment standard. A particular waste may be significantly different from the wastes on which the treatment standards are based because the subject waste contains a more complex matrix that makes it more difficult to treat. For example, complex mixtures may be formed when a restricted waste is mixed with other waste streams by spills or other forms of inadvertent mixing. As a result, the treatability of the restricted waste may be altered such that it cannot meet the applicable treatment standard.

Variance petitions must demonstrate that the treatment standard established for a given waste cannot be met. This demonstration can be made by showing that attempts to treat the waste by available technologies were not successful or by performing appropriate analyses of the waste, including waste characteristics affecting performance, which demonstrate that the waste cannot be treated to the specified levels. Variances will not be granted based solely on a showing that adequate BDAT treatment capacity is unavailable. (Such demonstrations can be made according to the provisions in Part 268.5 of RCRA for case-by-case extensions of the effective date.) The Agency will consider granting generic petitions provided that representative data are submitted to support a variance for each facility covered by the petition.

Petitioners should submit at least one copy to:

The Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

An additional copy marked "Treatability Variance" should be submitted to:

Chief, Waste Treatment Branch
Office of Solid Waste (WH-565)
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Petitions containing confidential information should be sent with only the inner envelope marked "Treatability Variance" and "Confidential Business Information" and with the contents marked in accordance with the requirements of 40 CFR Part 2 (41 FR 36902, September 1, 1976, amended by 43 FR 4000).

The petition should contain the following information:

1. The petitioner's name and address.
2. A statement of the petitioner's interest in the proposed action.
3. The name, address, and EPA identification number of the facility generating the waste, and the name and telephone number of the plant contact.
4. The process(es) and feed materials generating the waste and an assessment of whether such process(es) or feed materials may produce a waste that is not covered by the demonstration.
5. A description of the waste sufficient for comparison with the waste considered by the Agency in developing BDAT, and an estimate of the average and maximum monthly and annual quantities of waste covered by the demonstration. (Note: The petitioner should consult the appropriate BDAT background document for determining the characteristics of the wastes considered in developing treatment standards.)
6. If the waste has been treated, a description of the system used for treating the waste, including the process design and operating conditions. The petition should include the reasons the treatment standards are not achievable and/or why the petitioner believes the standards are based on inappropriate technology for treating the waste. (Note: The petitioner should refer to the BDAT background document as guidance for determining the design and operating parameters that the Agency used in developing treatment standards.)
7. A description of the alternative treatment systems examined by the petitioner (if any); a description of the treatment system deemed appropriate by the petitioner for the waste in question: and, as appropriate, the concentrations in the treatment residual or extract of the treatment residual (i.e., using the TCLP, where appropriate, for stabilized metals) that can be achieved by applying such treatment to the waste.
8. A description of those parameters affecting treatment selection and waste characteristics that affect performance, including results of all analyses. (See Section 3 for a discussion of

waste characteristics affecting performance that the Agency has identified for the technology representing BDAT.)

9. The dates of the sampling and testing.
10. A description of the methodologies and equipment used to obtain representative samples.
11. A description of the sample handling and preparation techniques, including techniques used for extraction, containerization, and preservation of the samples.
12. A description of analytical procedures used, including QA/QC methods.

After receiving a petition for a variance, the Administrator may request any additional information or waste samples that may be required to evaluate and process the petition. Additionally, all petitioners must certify that the information provided to the Agency is accurate under 40 CFR 268.4(b).

In determining whether a variance will be granted, the Agency will first look at the design and operation of the treatment system being used. If EPA determines that the technology and operation are consistent with BDAT, the Agency will evaluate the waste to determine if the waste matrix and/or physical parameters are such that the BDAT treatment standards reflect treatment of this waste. Essentially, this latter analysis will concern the parameters affecting treatment selection and waste characteristics affecting performance parameters.

In cases where BDAT is based on more than one technology, the petitioner will need to demonstrate that the treatment standard cannot be met using any of the technologies, or that none of the technologies are appropriate for treatment of the waste. After the Agency has made a determination on the petition, the Agency's findings will be published in the _Federal Register_, followed by a 30-day period for public comment. After review of the public comments, EPA will publish its final determination in the _Federal Register_ as an amendment to the treatment standards in 40 CFR Part 268, Subpart D.

2. INDUSTRY AFFECTED AND WASTE CHARACTERIZATION

The purpose of this section is to describe the industry that will be affected by land disposal restrictions on waste codes K103 and K104 and to characterize these wastes. This section includes a description of the industry affected and the production processes employed in this industry as well as a discussion of how K103 and K104 wastes are generated by these processes. The section concludes with a characterization of the K103 and K104 waste streams and a determination of the waste treatability group for these wastes.

The full list of hazardous waste codes from specific sources is given in 40 CFR 261.32 (see discussion in Section 1 of this document). Within this list, two specific hazardous waste codes are generated by the aniline/nitrobenzene industry:

K103: Process residues from aniline extraction from the production of aniline.

K104: Combined wastewater streams generated from nitrobenzene/aniline production.

The Agency has determined that these waste codes (K103 and K104) represent a separate waste treatability group. Industry processes are similar; therefore, the wastes are expected to have similar physical and chemical characteristics (see Section 1 for a discussion of waste treatability groups). In addition, these wastes are frequently mixed in industry prior to treatment. As a result, the Agency has examined the sources of the wastes, applicable treatment technologies, and treatment performance attainable in order to support a single regulatory approach for the two wastes.

2.1 Industry Affected and Process Description

The four-digit Standard Industrial Classification (SIC) code reported for the aniline/nitrobenzene industry is 2869. The Agency estimates that six facilities in the United States are actively involved in aniline production that could generate K103. Four of these facilities are actively co-producing aniline and nitrobenzene and could generate K104 waste.

Information from trade associations provides a geographic distribution of the number of these facilities across the United States. Tables 2-1 and 2-2 present the location of those facilities that may generate waste codes K103 and K104 in each State and in each EPA region. As can be seen in Tables 2-1 and 2-2, these facilities are concentrated in the central and eastern states (EPA Regions III through VI). Figure 2-1 illustrates this data plotted on a map of the United States.

Nitrobenzene is manufactured by either liquid or vapor phase nitration of benzene. The liquid phase nitration process is reported to be the more prevalent of the two processes used to manufacture nitrobenzene. In liquid phase nitration, benzene is nitrated in a reactor with an aqueous mixture of sulfuric acid and nitric acid (see Figure 2-2). Crude nitrobenzene is formed and is separated from the reactants and byproducts by a series of purification steps.

In the initial nitrobenzene purification step, the product stream from the reactor enters a separator, where it is cooled and allowed to settle and to separate by gravity into an organic phase and an aqueous phase. The aqueous phase, consisting mainly of untreated sulfuric and nitric acid, goes to the denitrator, where fresh benzene is added to

Table 2-1 Facilities Producing K103 and K104 (Listed by State)

State (EPA Region)	Number of facilities
Louisiana (VI)	1
Mississippi (IV)	1
North Carolina (IV)	1
Ohio (V)	1
Texas (VI)	1
West Virginia (III)	1
Total	6

Reference: SRI 1985.

Table 2-2 Facilities Producing K103 and K104 (Totals by Region)

EPA Region	Number of facilities
III	1
IV	2
V	1
VI	2
Total	6

Reference: SRI 1985.

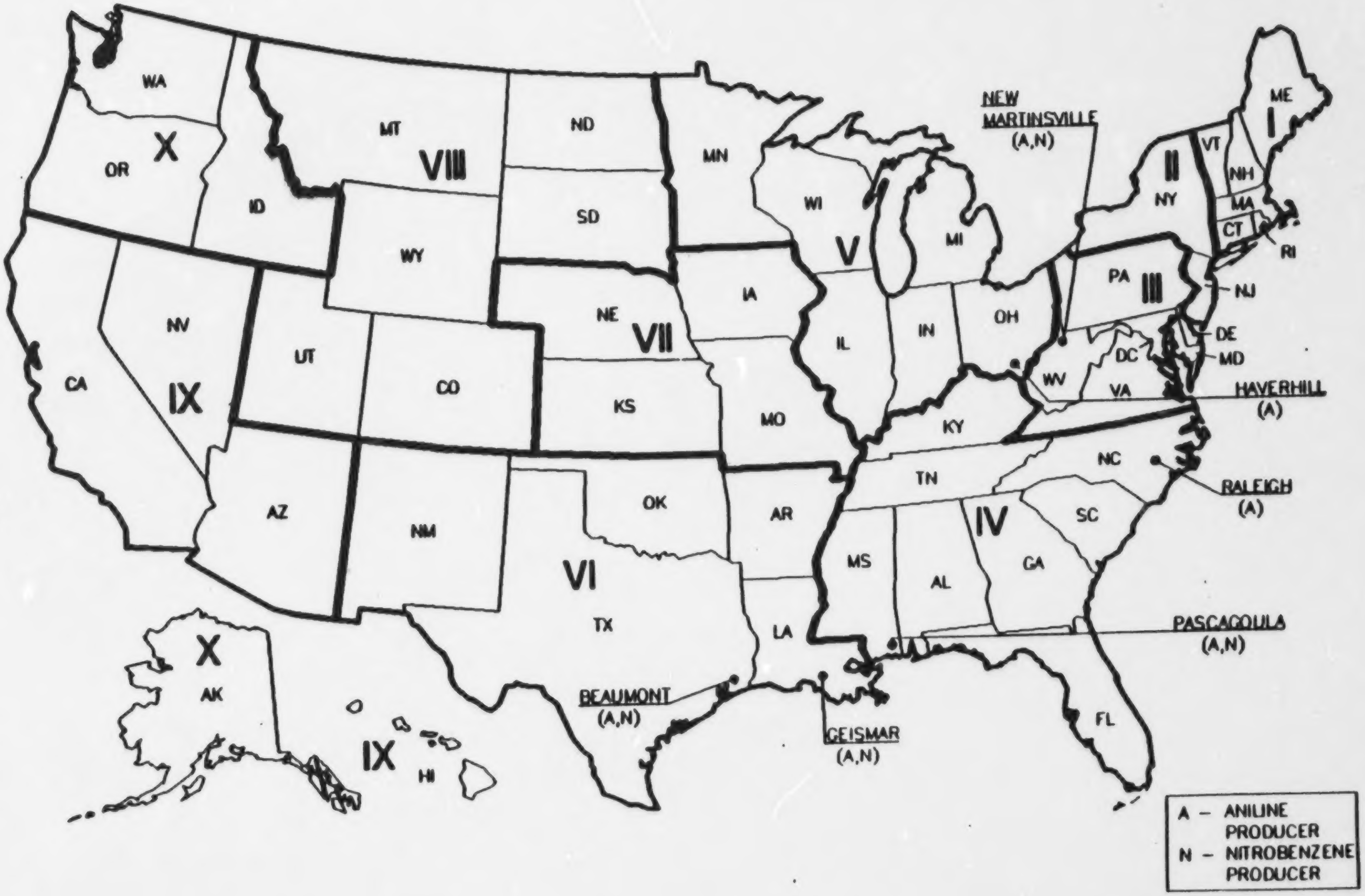
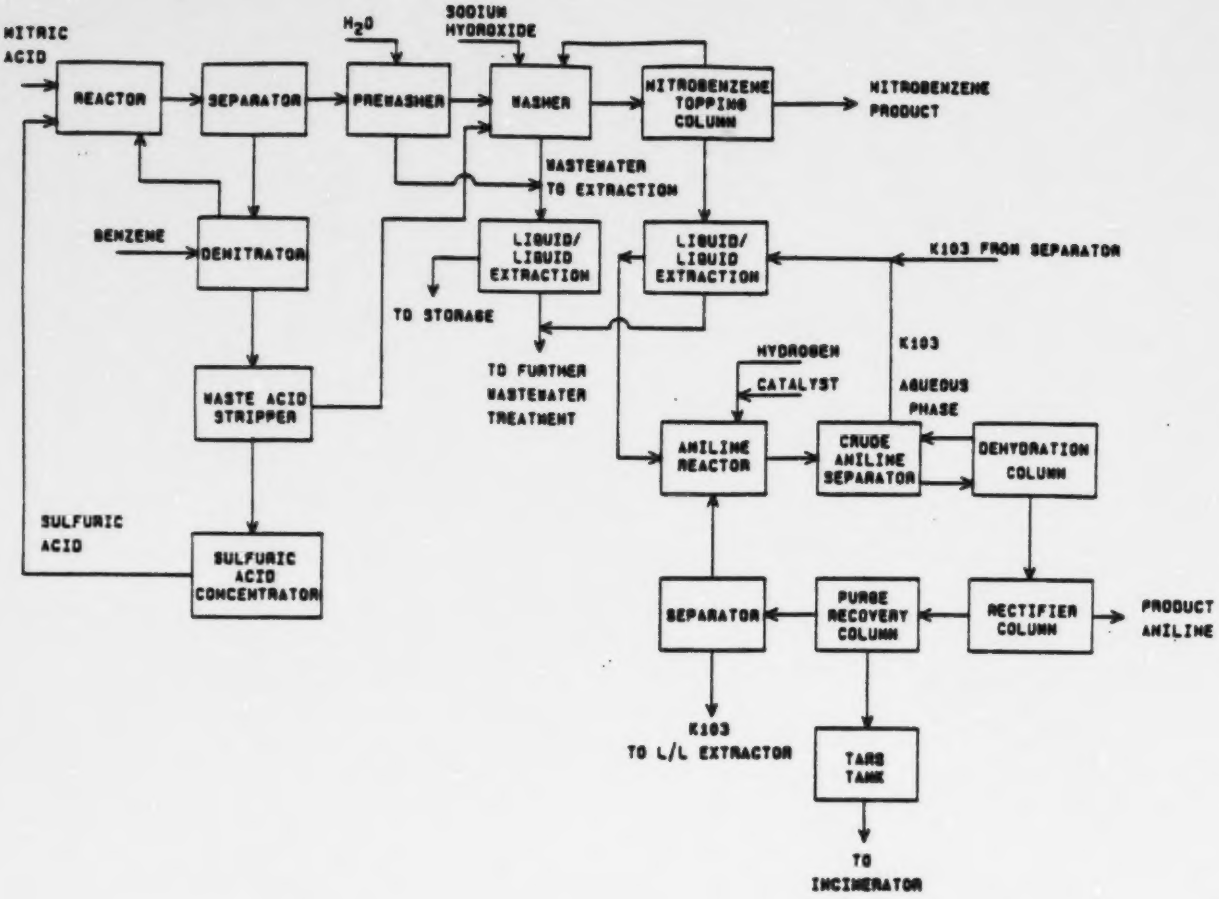

NEW MARTINSVILLE (A,N)
HAVERHILL (A)
RALEIGH (A)
PASCAGOULA (A,N)
GEISMAR (A,N)
BEAUMONT (A,N)
A – ANILINE PRODUCER
N – NITROBENZENE PRODUCER
I
II
III
IV
V
VI
VII
VIII
IX
X
WA
OR
ID
MT
ND
SD
WY
NV
CA
UT
CO
AZ
NM
NE
KS
OK
TX
MN
IA
MO
AR
LA
WI
IL
MI
IN
OH
KY
TN
MS
AL
GA
FL
SC
NC
VA
WV
DC
MD
DE
NJ
PA
NY
VT
NH
ME
MA
CT
RI
AK
HI

FIGURE 2-1 FACILITIES PRODUCING K103 AND K104 BY STATE AND EPA REGION


NITRIC ACID
REACTOR
SEPARATOR
H2O
PREWASHER
SODIUM HYDROXIDE
WASHER
NITROBENZENE TOPPING COLUMN
NITROBENZENE PRODUCT
WASTEWATER TO EXTRACTION
BENZENE
DENITRATOR
LIQUID/ LIQUID EXTRACTION
TO STORAGE
LIQUID/ LIQUID EXTRACTION
K103 FROM SEPARATOR
TO FURTHER WASTEWATER TREATMENT
WASTE ACID STRIPPER
HYDROGEN
CATALYST
K103
AQUEOUS PHASE
ANILINE REACTOR
CRUDE ANILINE SEPARATOR
DEHYDRATION COLUMN
SULFURIC ACID
SULFURIC ACID CONCENTRATOR
SEPARATOR
PURGE RECOVERY COLUMN
RECTIFIER COLUMN
PRODUCT ANILINE
K103 TO L/L EXTRACTOR
TARS TANK
TO INCINERATOR

REFERENCE: Delisting Petition For Waste Stream K104 - Combined Wastewater Streams Generated from Nitrobenzene/Aniline Production. Petition No. 0312.

Figure 2-2 Generation of K103 and K104 from Nitrobenzene/Aniline Production (Liquid Phase Nitration Of Benzene and Liquid Phase Reduction Of Nitrobenzene)

remove trace amounts of nitric acid. The benzene and trace amounts of nitrobenzene, formed in the denitrator, are returned to the nitrobenzene reactor. The acid phase from the denitrator is sent to the waste acid stripper for acid recovery by volatilization. The recovered acid from the waste acid stripper is recycled through an acid concentrator to the reactor.

The organic phase from the separator, consisting mainly of nitrobenzene, is washed with water in a prewasher and with caustic soda in a washer to remove traces of acid. The washwater streams from the prewasher and washer are both sent to a wastewater extractor, where nitrobenzene is recovered from the washwater (or wastewater). In the final purification step, the nitrobenzene stream from the washer is distilled in the nitrobenzene topping column to produce a high-purity nitrobenzene product.

Aniline is produced by reducing nitrobenzene with hydrogen in the presence of a catalyst. The three alternative reduction processes currently in use are the catalytic vapor phase, catalytic liquid phase, and dissolving metal (or Bechamp) processes. Most of the aniline in the United States is reported to be produced by the catalytic vapor phase and catalytic liquid phase processes.

In the catalytic liquid phase process, nitrobenzene is reduced by hydrogen to form aniline in the presence of a nickel catalyst in a reactor (see Figure 2-2). The crude aniline from the reactor is separated from water and other byproducts in a two-stage gravity decantation process consisting of a crude aniline separator and a separator. The water phases from both separators are combined and sent to the aniline liquid/liquid extractor, which recovers aniline from the residual wastewater stream. The aniline stream from the crude aniline separator is distilled in a rectification column to produce a high-purity aniline product.

The listed wastes K103 and K104 are generated in the manufacture of aniline and aniline/nitrobenzene, respectively. The generation of these wastes is discussed further in Sections 2.1.1 and 2.1.2.

2.1.1 Generation of K103 Waste

The listed waste K103 is generated in the production of aniline in both the crude aniline separator and the aniline/water separator after the rectifier column. In the crude aniline separator (see Figure 2-2), the product stream from the aniline reactor is cooled and allowed to settle and separate by gravity into an organic phase and an aqueous phase. The aqueous phase, which is the listed waste K103, is pumped to the aniline liquid/liquid extractor.

The bottoms stream from the rectifier column that purifies the crude aniline enters a purge recovery column, which separates water and aniline by distillation. The aniline-containing stream from the purge recovery columns enters a separator, where it is cooled and allowed to settle and separate by gravity into an organic phase and an aqueous phase. The organic phase, consisting mainly of aniline, is recycled to the aniline reactor. The aqueous phase, which is the listed waste K103, is combined with the aqueous phase from the crude aniline separator and pumped to the aniline liquid/liquid extractor. The bottoms from the purge recovery column are stored in the tars tank and eventually incinerated.

2.1.2 Generation of K104 Waste

The listed waste K104 is a combined wastewater generated in the co-production of nitrobenzene and aniline. In the prewasher, water is used to remove acid from the nitrobenzene stream coming from the separator by exploiting the relatively high solubility of the acids in water. An organic phase, consisting mainly of nitrobenzene, is separated from the aqueous phase in the prewasher and is sent to the washer. The aqueous phase from the prewasher is sent to the nitrobenzene liquid/liquid extractor.

In the washer, caustic soda is used to neutralize remaining traces of acid in the nitrobenzene stream from the prewasher. As before, organic and aqueous phases are formed by settling and gravity separation. Nitrobenzene is removed with the organic phase from the washer and enters the nitrobenzene topping column. The aqueous phase from the washer is combined with the aqueous phase from the prewasher and enters the nitrobenzene liquid/liquid extractor.

2.2 Waste Characterization

This section includes all waste characterization data available to the Agency for the K103 and K104 waste treatability group. An estimate of the major constituents that compose each waste and their approximate concentrations is presented in Table 2-3. The percent concentration of each major constituent in the waste was determined from best estimates based on chemical analyses. Table 2-3 shows that the major constituent of both K103 and K104 is water (at >94.7 percent and >98.7 percent, respectively). The primary organic BDAT constituent in K103 is aniline, with benzene and sulfide being the other primary BDAT constituents present (<1.0 percent). The primary organic BDAT constituent in K104 is nitrobenzene, benzene and cyanides being the other primary BDAT constituents present (<1.0 percent).

The ranges of BDAT constituents present in each waste and all other available data concerning waste characterization parameters obtained from the Onsite Engineering Report for E. I. duPont de Nemours, Beaumont, Texas, are presented by waste code in Table 2-4. This table lists the levels of BDAT organics (volatile and semivolatile), metals, and inorganics present in K103 and K104 wastes. Other parameters analyzed in the wastes include total dissolved solids, total suspended solids, total organic carbon, and chemical oxygen demand. Tables 2-3 and 2-4 together provide a thorough characterization of K103 and K104 wastes.

Table 2-3 Major Constituent Composition for K103 and K104 Wastes[a]

Constituent	K103 waste concentration (wt. percent)
Water	>94.7
Aniline	4.3
BDAT constituents (other than aniline)	<1.0
Total	100.0%

Constituent	K104 waste concentration (wt. percent)
Water	>98.7
Nitrobenzene	0.3
BDAT constituents (other than nitrobenzene)	<1.0
Total	100.0

[a] Percent concentrations presented here were determined from best estimates based on chemical analyses.

Reference: USEPA. 1987. Onsite engineering report for E. I. duPont de Nemours, Beaumont, Texas. Pages 6 and 8.

Table 2-4 BDAT Constituent Analysis and Other Data

	Untreated Waste Concentration Range, mg/l [a]	
BDAT ORGANICS	K103	K104
Volatile	32 - 81	4.5 - 320
4. Benzene		
Semivolatile		
56. Aniline	33,000 - 53,000	<150 - <300
101. 2,4-Dinitrophenol[b]	<7,500 - <15,000	750 - <1,500
126. Nitrobenzene[b]	1,900 - 2,800[c]	2,200 - 3,900
142. Phenol	1,500 - <3,000	<150 - <300
BDAT Metals		
155. Arsenic	0.01 - 21	<0.01
156. Barium	<.001	.0015 - .017
159. Chromium	<.007	<.007 - .432
160. Copper	<.006	<.006 - .012
161. Lead	<.005 - 6	<.020
161. Nickel	<.011	<.011 - .238
168. Zinc	3 - 21	<.038 - .079
BDAT Inorganics		
169. Total Cyanides		
171. Sulfide	<0.010 - 0.075	3.06 - 6.28
	62 - 89	<1.0
Other Parameters		
Total Dissolved Solids	d	10,200 - 27,200
Total Suspended Solids	8 - 24	21 - 172
Total Organic Carbon	33,500 - 36,300	1,420 - 2,990
Chemical Oxygen Demand	97,800 - 111,000	5,290 - 48,200

[a] Values obtained from Onsite engineering report of Treatment Technology Performance for E.I. du Pont de Nemours, Inc., Beaumont, Texas. Tables 6-6 and 6-8.

[b] Data from the Effluent Limitations Guideline Data Base show untreated nitrobenzene in the range 87 - 5,460 ppm and untreated 2,4-dinitrophenol in the range 20 - 58 mg/l.

[c] Value represents the treated waste from the aniline liquid/liquid extractor. Nitrobenzene was used as a solvent in the aniline liquid/liquid extractor.

[d] Total dissolved solids could not be analyzed since the sample flashed before an analysis could be completed. This was the result of the amount of organics contained in the sample.

3. APPLICABLE/DEMONSTRATED TREATMENT TECHNOLOGIES

The purpose of this section is to describe applicable treatment technologies for treatment of K103 and K104 wastes that the Agency has identified as applicable and to describe which of the applicable technologies the Agency has determined to be demonstrated. Included in this section are discussions of those applicable treatment technologies that have been demonstrated on a commercial basis. The technologies considered to be applicable are those that treat organic compounds by concentration reduction.

The previous section described the industry that will be affected by the land disposal restrictions on K103 and K104 wastes and presented a characterization of these wastes. Analysis of the K103 wastewaters indicates that they primarily consist of water (94.7 percent) and aniline (4.3 percent). The K104 wastewater primarily consists of water (98.7 percent), nitrobenzene (0.3 percent), and small amounts of cyanides. The Agency has identified treatment technologies that may be applicable to K103 and K104 because the technologies are designed to reduce the concentration of organic compounds present in the untreated waste. The selection of the treatment technologies applicable for treating organic compounds and cyanides in K103 and K104 wastewaters is based on information obtained from engineering site visits and available literature sources.

3.1 Applicable Treatment Technologies

For K103 and K104 wastewaters, the Agency has identified the following treatment technologies as being applicable: liquid/liquid (or solvent) extraction, which separates the organic components from the aqueous components by exploiting the relative differential or selective solubility of the organic constituents in a particular solvent; steam stripping, which removes organics from the liquid phase through volatilization; activated carbon adsorption, which uses carbon granules to selectively remove organic contaminants by adsorption; and biological treatment, which involves the use of microorganisms to degrade organic compounds.

The use of activated carbon adsorption in treating the wastewaters generates a spent carbon that is a nonwastewater. Spent carbon will generally be regenerated by a thermal process, such as low temperature incineration (700°C) or steam stripping. In both cases, the wastewaters generated will be similar to K103 and K104 wastewaters and can be treated accordingly. After several cycles of regeneration and reuse, the spent carbon is discarded. The Agency has identified rotary kiln incineration as being an applicable treatment technology for this nonwastewater form of K103 and K104.

Another nonwastewater stream is generated from the nitrobenzene liquid/liquid extractor; it may be recycled or returned to the process stream. If it is incinerated as a waste, special consideration must be given because of the possible reactive nature of the waste.

3.2 Demonstrated Treatment Technologies

Nonwastewaters

The demonstrated technology that the Agency has identified for treatment of K103 and K104 nonwastewaters is rotary kiln incineration.

This technology is not currently being used for the treatment of K103 and K104 nonwastewaters, but it is used for wastes similar to K103 and K104 nonwastewaters. Accordingly, EPA believes this technology is demonstrated for K103 and K104.

Wastewaters

The Agency has determined that all of the applicable technologies for wastewaters are demonstrated. Solvent extraction is a demonstrated treatment technology. The facility tested has used this technology on a full-scale basis for K103 and K104. Solvent extraction is regularly used for the separation of organics in manufacturing processes and waste treatment. For example, solvent extraction is used in the petroleum refining industry, both in product processes and waste treatment.* Waste characteristics affecting the performance of solvent extraction include the following: total organic carbon, filterable solids, viscosity, and BDAT list metals content. The demonstrated treatment technologies listed above for K103 and K104, generally, are combined to form treatment systems or treatment trains, which are more effective than single technologies alone in removing and recovering organics from wastewater. The three treatment technology systems that are demonstrated or are currently in commercial use are as follows:

- Liquid/liquid extraction followed by steam stripping and activated carbon adsorption;
- Steam stripping followed by activated carbon adsorption; and
- Steam stripping followed by biological treatment.

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* For a further discussion on the use of solvent extraction in waste treatment systems, refer to Section 3 of the Background Document for K048-52 (Petroleum Refinery Wastes).

A more detailed discussion of the treatment technology system for which the Agency has collected performance data is presented in Sections 3.2.1 through 3.2.3.

3.2.1 Solvent Extraction

Solvent extraction is a treatment technology used to remove a constituent from a waste by mixing the waste with a solvent that is immiscible with the waste and in which the waste constituent of concern is preferentially soluble. Solvent extraction is commonly called liquid extraction or liquid-liquid extraction. EPA also uses this term to refer to extraction of BDAT list organics from a solid waste. When BDAT list metals are extracted using acids, EPA uses the term acid leaching.

(1) Applicability and use of solvent extraction. Theoretically, solvent extraction has broad applicability in that it can be used for wastes that have high or low concentrations of a range of waste characteristics including total organic carbon, filterable solids, viscosity, and BDAT list metals content. The key to its use is whether the BDAT constituents can be extracted from the waste matrix containing the constituents of concern. For a waste matrix with high filterable solids, this would mean that the solids could be land disposed following solvent extraction. For a predominately liquid waste matrix with low filterable solids, the extracted liquid (referred to as the raffinate) could be reused. Solvent extraction can seldom be used without additional treatment (e.g., incineration) of the extract; however, some industries may be able to recycle the solvent stream contaminated with the BDAT constituents back to the process.

(2) Underlying principles of operation. For solvent extraction to occur, the BDAT constituents of concern in the waste stream must be preferentially soluble in the solvent and the solvent must be essentially immiscible with the waste stream. In theory, the degree of separation that can be achieved is provided by the selectivity value; this value is the ratio of the equilibrium concentration of the constituent in the solvent to the equilibrium concentration of the constituent in the waste.

The solvent and waste stream are mixed to allow mass transfer of the constituent(s) from the waste stream to the solvent. The solvent and waste stream are then allowed to separate under quiescent conditions. The solvent solution containing the extracted contaminant is called the extract. The extracted waste stream with the contaminants removed is called the raffinate. The simplest extraction system comprises three components: (1) the solute, or the contaminant to be extracted; (2) the solvent; and (3) the nonsolute portion of the waste stream. For simple extractions, solute passes from the waste stream to the solvent phase. A density difference exists between the solvent and waste stream phases. The extract can be either the heavy phase or the light phase.

(3) Physical description of a solvent extraction process. The simplest method of extraction is a single-stage system. The solvent and waste stream are brought together; clean effluent and solvent are recovered without further extraction. The clean effluent is referred to as the raffinate, and the solvent containing the constituents that were removed from the waste stream are known as the extract. The amount of

solute extracted is fixed by equilibrium relations and the quantity of solvent used. Single-stage extraction is the least effective extraction system.

Another method of extraction is simple multistage contact extraction. In this system, the total quantity of solvent to be used is divided into several portions. The waste stream is contacted with each of these portions of fresh solvent in a series of successive steps or stages. Raffinate from the first extraction stage is contacted with fresh solvent in a second stage, and so on.

In countercurrent, multistage contact, fresh solvent and the waste stream enter at opposite ends of a series of extraction stages. Extract and raffinate layers pass continuously and countercurrently from stage to stage through the system.

In order to achieve a reasonable approximation of phase equilibrium, solvent extraction requires the intimate contacting of the phases. Several types of extraction systems are used for contact and separation; two of these, mixer-settler systems and column contactors, are discussed below.

(a) Mixer-settler systems. Mixer-settler systems are comprised of a mixing chamber for phase dispersion, followed by a settling chamber for phase separation. The vessels may be either vertical or horizontal. Dispersion in the mixing chamber occurs by pump circulation, nonmechanical in-line mixing, air agitation, or mechanical stirring. In a two-stage mixer-settler system, the dispersed phase separates in a horizontal settler. The extract from the second settler is recycled to the first settler (see Figure 3-1). Extract properties such as density or specific constituent concentration may be monitored to determine when the extract must be sent to solvent recovery and fresh or regenerated solvent added to the system. Mixer-settler systems can handle solids or highly viscous liquids. Design scaleup is reliable, and mixer-settlers can handle difficult dispersion systems. Intense agitation to provide high rates of mass transfer can produce solvent-feed dispersions that are difficult to separate into distinct phases.

(b) Column contactors. Packed and sieve-tray are two different types of column contactors that do not require mechanical agitation. Figure 3-2 presents schematics of the two types of extraction columns.

A packed extractor contains packing materials, such as saddles, rings, or structured packings of gauze or mesh. Mass transfer of the solute to the extract is promoted because of breakup and distortion of the dispersed phase as it contacts the packing.

The sieve-tray extractor is similar to a sieve-tray column used in distillation. Tray perforations result in the formation of liquid droplets to aid the mass transfer process. The improved transfer is accomplished by the fact that the droplets allow for more intimate contact between extract and raffinate.

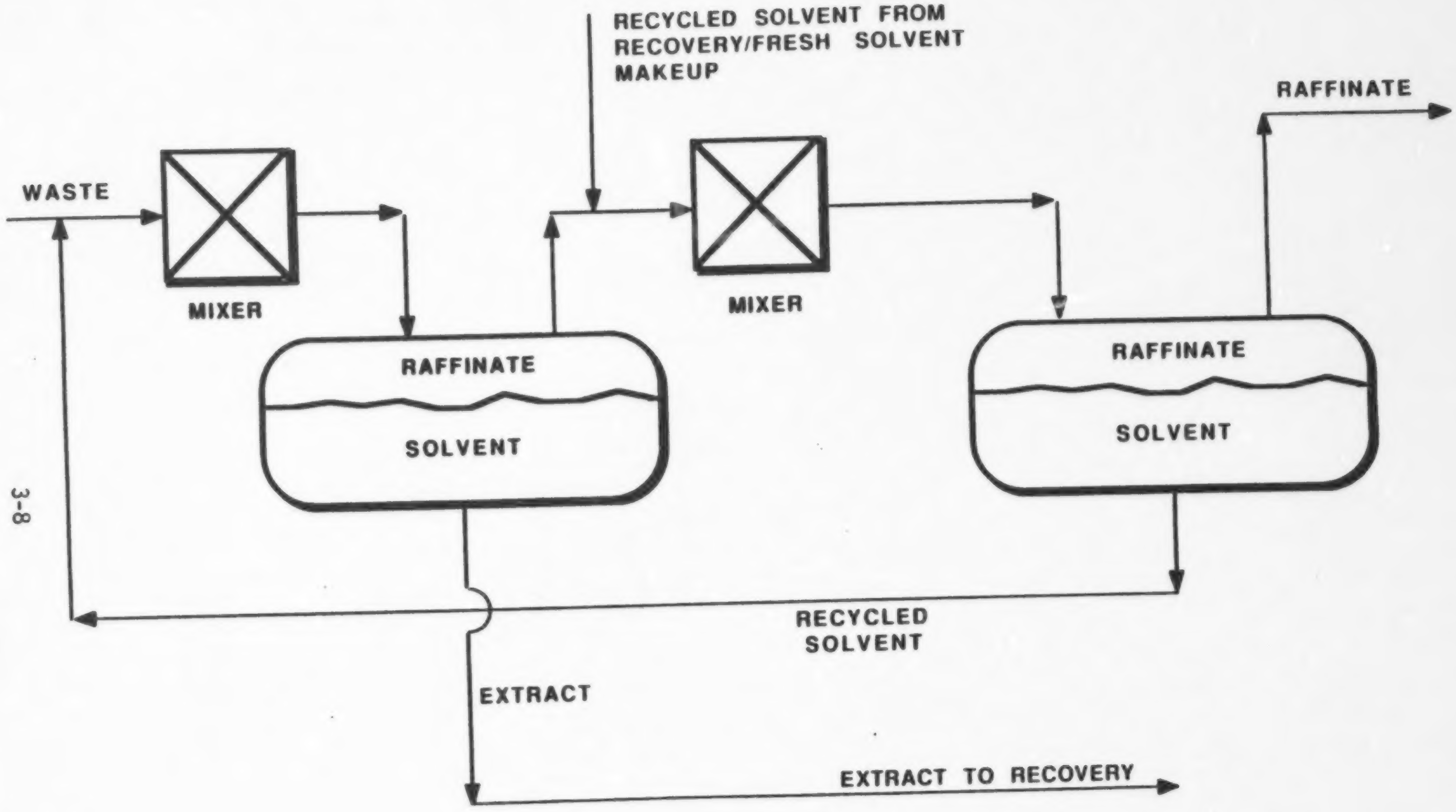
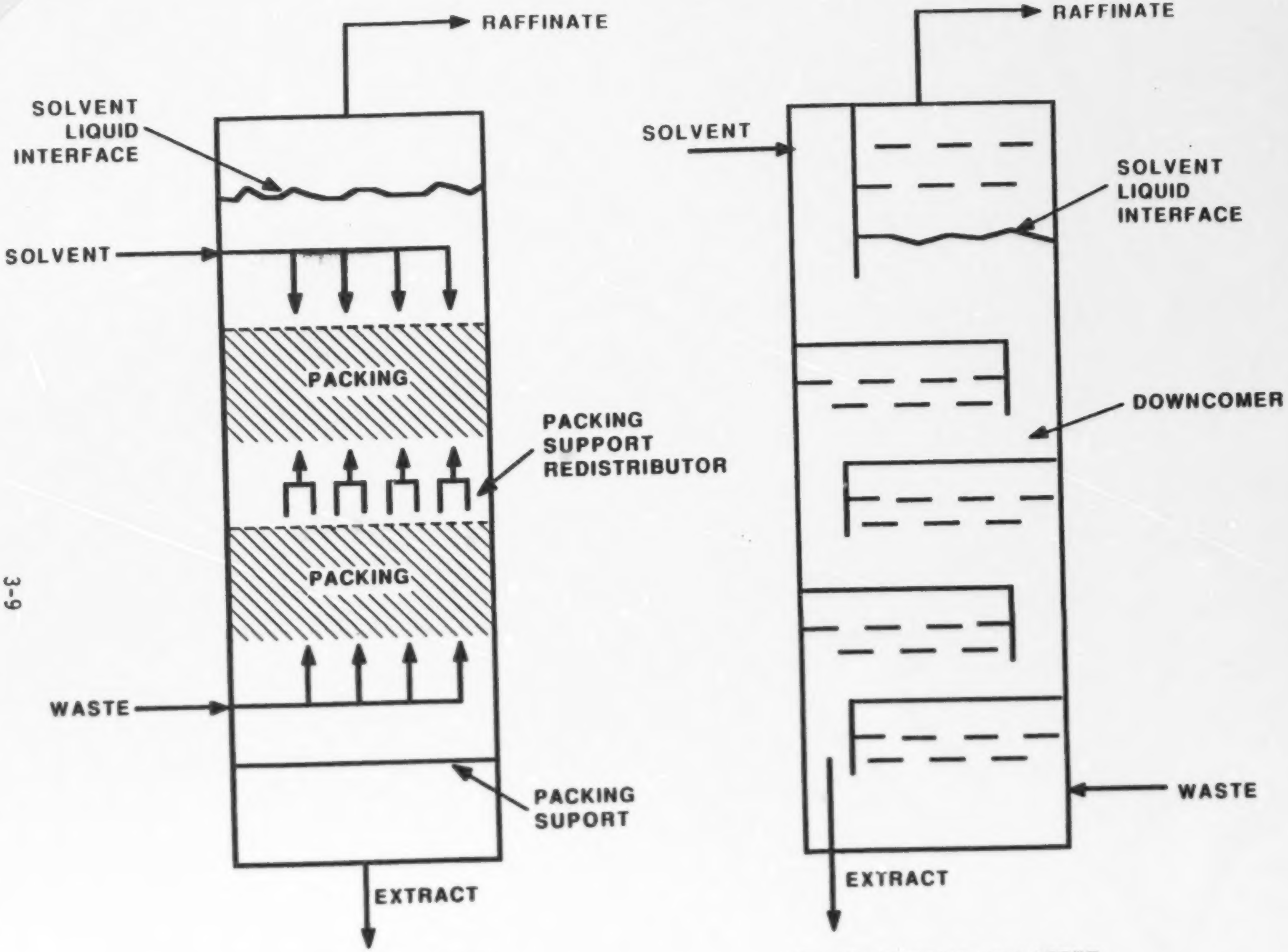

RECYCLED SOLVENT FROM
RECOVERY/FRESH SOLVENT
MAKEUP
RAFFINATE
WASTE
MIXER
MIXER
RAFFINATE
SOLVENT
RAFFINATE
SOLVENT
RECYCLED
SOLVENT
EXTRACT
EXTRACT TO RECOVERY

Figure 3-1

TWO-STAGE MIXER-SETTLER EXTRACTION SYSTEM


RAFFINATE
SOLVENT LIQUID INTERFACE
SOLVENT
PACKING
PACKING SUPPORT REDISTRIBUTOR
PACKING
WASTE
PACKING SUPORT
EXTRACT
RAFFINATE
SOLVENT
SOLVENT LIQUID INTERFACE
DOWNCOMER
WASTE
EXTRACT

A. PACKED EXTRACTOR

B. SIEVE TRAY EXTRACTOR

Figure 3-2

EXTRACTION COLUMNS WITH NONMECHANICAL AGITATION

(4) Waste characteristics affecting performance. In determining whether solvent extraction is likely to achieve the same level of performance on an untested waste as on a previously tested waste, the Agency will focus on the waste characteristics that provide an estimate of the selectivity value previously described. EPA believes that the selectivity value can best be estimated by analytically measuring the partitioning coefficients of the waste constituents of concern and the solubility of the waste matrix in the extraction solvent. Accordingly, EPA will use partitioning coefficients and solubility of the waste matrix as surrogates for the selectivity value in making decisions regarding transfer of treatment standards.

For the liquid/liquid extraction system, the WCAPs are the relative solubilities (a measure of the partitioning coefficient) of the various waste constituents in water and in nitrobenzene. The primary organic constituents of K103 and K104 (benzene, aniline, nitrobenzene, phenol, and 2,4-dinitrophenol), along with cyanides, are all soluble in nitrobenzene at 40°C. Phenol and cyanides are soluble in water at 40°C, while benzene, aniline, and nitrobenzene are relatively insoluble in water (0.137 g/100 g H_2O saturated solution at 54.5°C). It should also be noted that the density of nitrobenzene relative to water is 1.205 at 4°C.

(5) Design and operating parameters. EPA's analysis of whether a solvent extraction system is well designed will focus on whether the BDAT list constituents are likely to be effectively separated

from the waste. The particular design and operating parameters to be evaluated are: (1) the selection of a solvent, (2) equilibrium data, (3) temperature and pH, (4) mixing, and (5) settling time.

(a) The selection of a solvent. In assessing the design of a solvent extraction system, the most important aspect to evaluate is the solvent used and the basis on which the particular solvent was selected. Solvent selection is important because, as indicated previously, different waste constituents of concern will have different solubilities in various solvents, and it is the extent to which the waste constituents are preferentially soluble in the selected solvent that determines the effectiveness of this technology. In addition to this information, EPA reviews any empirical extraction data used to design the system.

(b) Equilibrium data. For solvent extraction systems that are operated in a continuous mode, the extraction process will generally be conducted using a series of equilibrium stages as discussed previously. The number of equilibrium stages and the associated flow rates of the waste and solvent will be based on empirical equilibrium data. EPA evaluates these data as part of assessing the design of the system.

(c) Temperature and pH. Temperature and pH changes can affect equilibrium conditions and, consequently, the performance of the extraction system. Thus, it is important to attempt to monitor and record these values on a continuous basis.

(d) Mixing. For mixer-settler type extraction processes, mixing determines the amount of contact between the two immiscible phases and, accordingly, the degree of mass transfer of the constituents to be extracted. Therefore, it is important to identify the type of mixers used and the basis for determining that this system would provide sufficient mixing.

(e) Settling time. For batch systems, adequate settling time must be allowed to ensure that separation of the phases has been completed. Accordingly, in assessing the design of a system, the settling time allowed and the basis for selection must be identified.

3.2.2 Steam Stripping

Steam stripping is a technology that can separate more volatile materials from less volatile materials by a process of vaporization and condensation. As such, it is a type of distillation process.

(1) Applicability and use of steam stripping. Steam stripping is applicable to wastewaters that contain BDAT organics that are sufficiently volatile such that they can be removed by the application of steam. Waste parameters affecting treatment selection are filterable solids, total organic carbon (TOC), and the presence of BDAT organics that are either not volatile or only minimally volatile.

(2) Underlying principles of operation. The basic principle of operation for steam stripping is the volatilization of hazardous constituents through the application of heat. The constituents that are volatilized are then condensed and either reused or further treated by liquid injection incineration.

An integral part of the theory of steam stripping is the principle of vapor-liquid equilibrium. When a liquid mixture of two or more components is heated, a vapor phase is created above the liquid phase. The vapor phase will be more concentrated in the constituents having the higher vapor pressure. If the vapor phase above the liquid phase is cooled to yield a condensate, a partial separation of the components results. The degree of separation would depend on the relative differences in the vapor pressures of the constituents; the larger the difference in the vapor pressure, the more easily the separation can be accomplished.

If the difference between the vapor pressures is extremely large, a single separation cycle or single equilibrium stage of vaporization and condensation may achieve a significant separation of the constituents. If the difference between the vapor pressures is small, then multiple equilibrium stages are needed to achieve effective separation. In practice, the multiple equilibrium stages are obtained by stacking trays or placing packing into a column. The vapor phase from a tray rises to the tray above it and the liquid phase falls to the tray below it. Essentially, each tray represents one equilibrium stage. In a packed steam stripping column, the individual equilibrium stages are not discernible, but the number of equivalent trays can be calculated from mathematical relationships.

The vapor-liquid equilibrium is expressed as relative volatility or the ratio of the vapor-to-liquid concentration for a constituent divided by the ratio of the vapor-to-liquid concentration of the other constituent. The relative volatility is a direct measure of the ease of separation. If the numerical value is 1, then separation is impossible because the constituents have the same concentrations in the vapor and liquid phases. Separation becomes easier as the value of the relative volatility becomes increasingly greater than unity.

(3) Physical description of the process. A steam stripping unit consists of a boiler, a stripping section, a condenser, and a collection tank as shown by Figure 3-3. The boiler provides the heat required to vaporize the liquid fraction of the waste. The stripping section is composed of a set of trays or packing in a vertical column. The feed enters at the top.

The stripping process uses multiple equilibrium stages, with the initial waste mixture entering the uppermost equilibrium stage. The boiler is located below the lowermost equilibrium stage so that vapor generated moves upward in the column, coming into contact with the falling liquid. As the vapor comes into contact with the liquid at each stage, the more volatile components are removed or "stripped" from the liquid by the vapor phase. The concentration of the emerging vapor is slightly enriched (as it is in equilibrium with the incoming liquid), and the liquid exiting the bottom of the boiler ("bottoms") is considerably enriched in the lower vapor pressure constituent(s). The process of stripping is very effective for wastewaters where the relative volatilities are large between the organics of concern and wastewater. Steam stripping is used to strip the organic volatiles from wastewater. The water effluent from the bottom of the stripper is reduced in organic

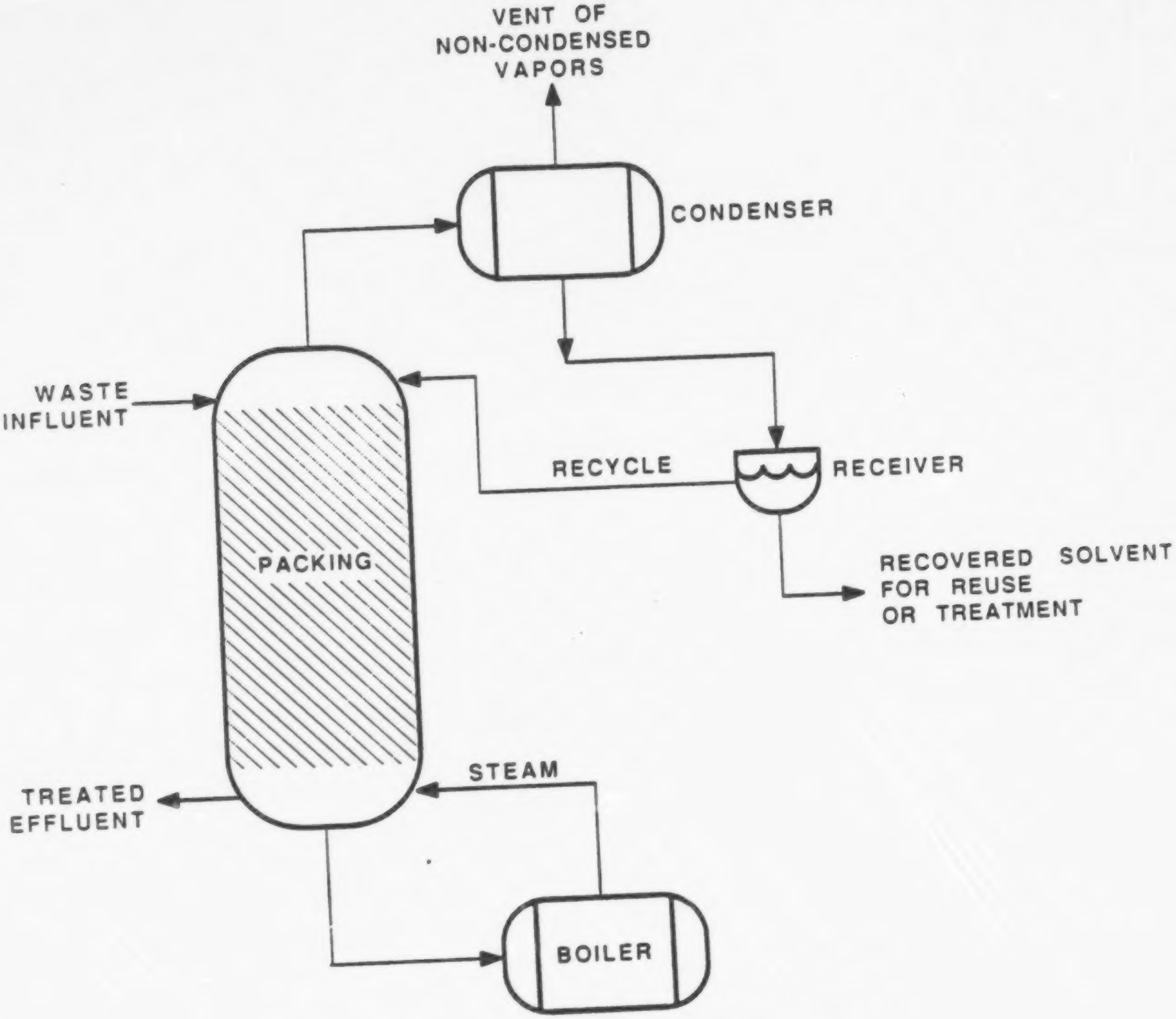

VENT OF
NON-CONDENSED
VAPORS
CONDENSER
WASTE
INFLUENT
RECYCLE
RECEIVER
PACKING
RECOVERED SOLVENT
FOR REUSE
OR TREATMENT
STEAM
TREATED
EFFLUENT
BOILER

Figure 3-3
STEAM STRIPPING

content, but in some circumstances may require additional treatment, such as carbon adsorption or biological treatment. The steam and organic vapors leaving the top of the column are condensed. Organics in the condensate that form a separate phase in water usually can be separated and recovered or disposed of in a liquid injection incinerator. After separation the aqueous condensate is usually recycled to the stripper.

(4) Waste characteristics affecting performance. In determining whether steam stripping is likely to achieve the same level of performance on an untested waste as on a previously tested waste, EPA will focus on the following characteristics: boiling point, total dissolved solids, total dissolved volatile solids, and oil and grease. EPA recognizes that these characteristics have some limitations in assessing transfer of performance; nevertheless, the Agency believes that they provide the best possible indicator of the preferred waste characteristic analysis, i.e., relative volatility. Below is a discussion of relative volatility, as well as EPA's rationale for evaluating the above-described waste characteristics in determining transfer of treatment performance.

As discussed earlier, the term relative volatility (α) refers to the ease with which a substance present in a solid or liquid waste will vaporize from that waste upon application of heat from an external source. Hence, it bears a relationship to the equilibrium vapor pressure of the substance.

For an ideal[*] binary mixture, the relative volatility (α) is expressed as:

$$\alpha = \frac{K_i}{K_j} = \frac{Y_iX_i}{Y_jX_j}$$

where K_i and K_j are equilibrium concentrations for components i and j respectively, Y is the mole fraction of the component in the vapor, and X is the mole fraction of the component in the liquid.

For non ideal binary mixtures, the relative volatility (α) is expressed as:

$$\alpha = \frac{K_i}{K_j} = \frac{Y_i}{X_i} \cdot \frac{f_{i,l}}{f_{i,v}} \Big/ \frac{Y_j}{X_j} \cdot \frac{f_{j,l}}{f_{j,v}}$$

where f is the fugacity. The term "fugacity" is a conveniently defined thermodynamic term to account for departures from ideal behavior of the gas and liquid; it can only be determined empirically.

EPA recognizes that the relative volatilities cannot be measured or calculated directly for the types of wastes generally treated by steam stripping even if these wastes behaved in an ideal manner. Determining relative volatilities is further complicated by the fact that the relative volatility changes as the temperature conditions change throughout the steam stripper. Accordingly, EPA will use the following surrogates: boiling point of the constituent, oil and grease content, total dissolved inorganic solids, and total dissolved volatile solids.

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[*] The term "ideal" refers to whether the vapor pressures of the two components can be linearly related to their respective compositions in the liquid phase; this is known as Raoult's law. In general, binary solutions at low pressures follow this law and are, therefore, "ideal"; most mixtures do not.

For a given pressure and temperature, compounds with lower boiling points will have higher vapor pressures. Therefore, in the case of wastewaters containing low concentrations of organics where relative volatility is effectively a comparison of vapor pressures, the ratio of boiling points of the untested and tested constituents will indicate whether the untested waste can be treated to the same degree as the tested constituent. Boiling point alone would not account for any non-ideal behavior of the solution. Accordingly, EPA will examine the concentrations of oil and grease, total dissolved solids, and total dissolved volatile solids. All of these characteristics affect the partial pressures of the individual organic constituents of concern as well as the solubility. Accordingly, these characteristics will affect relative volatility of a constituent and, hence, the ability of the constituent to be treated using steam stripping.

The waste characteristics affecting performance for the steam stripper are the vapor pressures of the various constituents in the waste. The higher the vapor pressure, the more easily stripped. At 40°C, benzene has a vapor pressure of 182.7 mm Hg, aniline has a vapor pressure of 2.90 mm Hg, and phenol has a vapor pressure of 2.02 mm Hg. Nitrobenzene has a vapor pressure of 1 mm Hg at 44.4°C, and 2,4-dinitrophenol has a vapor pressure of 1 mm Hg at 49.3°C. The cyanides present are primarily solid salts, and hence have low vapor pressures or decompose upon heating. There are no known azeotropes among the constituents of these wastes, and there is no known polymerization potential upon heating these wastes.

(5) Design and operating parameters. EPA's analysis of whether a steam stripping system is well designed focuses on the degree of separation the system is designed to achieve and the controls installed to maintain the proper operating conditions. The specific parameters are presented below.

(a) Treated and untreated concentrations. In determining whether to sample a particular steam stripper as a candidate for BDAT, EPA pays close attention to the treated design concentration of the unit to ensure that it is consistent with best demonstrated practice. This evaluation is important in that a treatment system will usually not perform its design. The various untreated waste characteristics that affect performance are important, because operation of the system with untreated waste concentrations in excess of initial design conditions can easily result in poor performance of the treatment unit. In evaluating the performance of a steam stripper, EPA reviews data on the untreated waste characteristics to ensure that these data conform with design specifications.

(b) Vapor-liquid equilibrium data. The vapor-liquid equilibrium data are determined in laboratory tests unless already available. The use of these data is required for several reasons. First, the data are used to calculate the number of theoretical stages required to achieve the desire separation. Using the theoretical number of stages, the actual number of stages can then be determined through the use of empirical tray efficiency data supplied by an equipment manufacturer.

Secondly, the vapor-liquid equilibrium data are used to determine the liquid and vapor flow rates that ensure sufficient contact between the liquid and vapor streams. These rates are, in turn, used to determine the column diameter.

(c) Column temperature and pressure. These parameters are integrally related to the vapor-liquid equilibrium conditions. Column temperature design includes performing a heat balance around the steam stripping unit, accounting for the heat removed in the condenser, heat input in the feed. heat input from steam injectors, and heat loss from the column. Column pressure influences the boiling point of the liquid. For example, the column temperature required to achieve the desired separation can be reduced by operating the system under vacuum. During treatment, it is important to continuously monitor these parameters to ensure that the system is operated at design conditions.

(d) Column internals. Column internals are designed to accommodate the physical and chemical properties of the wastewater to be stripped. Two types of internals may be used in steam stripping: trays or packing. Tray types include bubble cap, sieve, valve and turbo-grid. Trays have several advantages over packing. Trays are less susceptible to blockage by solids, have a lower capital cost for large diameter columns (greater than or equal to 3 feet), and accommodate a wider range of liquid and vapor flow rates. Compared to trays, packing has the advantages of having a lower pressure drop per theoretical stage, being more resistant to corrosive materials, having a lower capital cost for a small-diameter column (less than 3 feet), and finally being less susceptible to foaming because of a more uniform flow distribution.

3.2.3 Carbon Adsorption

Adsorption with activated carbon is an important separation method for removing organics and some other dissolved materials from liquids. It occurs when the surface of the activated carbon attracts the ions or molecules of the organic or dissolved solid to form a layer on the carbon surface and accumulate in its pores.

(1) Applicability and use of carbon adsorption. Activated carbon treatment is used to remove dissolved organic pollutants from aqueous streams. To a lesser extent it also is used to remove dissolved heavy metal and other inorganic contaminants. Inorganics are usually not very adsorbable, but there are some exceptions (e.g., molybdates, gold chloride, mercuric chloride, silver salts, and iodine). The most effective metals removal occurs with metal/inorganic complexes or metal organic complexes.

Activated carbon treatment is not selective in the organic contaminants it will remove. Hence, all organics will compete for system capacity, including organics that need not be removed. In some systems (downflow granular activated carbon beds), suspended solids over 50 mg/l cannot be tolerated and must be removed prior to activated carbon treatment. Activated carbon is frequently applied as a final polishing mechanism following other treatment technologies (e.g., biological treatment). These waste component separations most commonly occur in industries manufacturing organic chemicals, inorganic chemicals, dyes and pigments, insecticides, refineries, textiles, explosives, food, tobacco, leather, primary metals, fabricated metals, pharmaceuticals, and plastics.

(2) Underlying principles of operation. Activated carbon treatment is an application of the principle of adsorption. Adsorption is the mass transfer of a molecule from a liquid or gas into a solid surface.

Activated carbon is manufactured in such a way as to produce extremely porous carbon particles, whose internal surface area is very large (500 to 1400 square meters per gram of carbon). This porous structure, through chemical and physical forces, attracts and holds (adsorbs) organic molecules as well as certain inorganic molecules. It is not unusual for activated carbon to adsorb from aqueous solution 0.15 grams of an organic contaminant per gram of carbon, though 0.10 gram/gram is probably a more realistic general estimate. The principal factor that affects carbon adsorption is the chemical affinity between the carbon and the organic compound. Other characteristics such as solubility, temperature, pH, type of activated carbon used, and presence of other organics also influence the effectiveness of carbon adsorption.

The effectiveness of adsorption generally improves with increasing contact time. Exceptions to this rule include chemical compounds that are not preferentially adsorbed onto the carbon surface. These compounds can be adsorbed from adsorption sites in favor of compounds that have a higher affinity for the carbon over a longer contact time.

Once the contaminants/impurities have been removed from the waste stream onto the carbon, two options are available. The activated carbon can be (1) disposed of by approved methods (usually incineration) or (2) regenerated by thermal or chemical methods for further use.

There is a loss of performance with each regeneration step; therefore, the activity is never restored to its original level. The number of times that the carbon can be regenerated is determined by the extent of physical erosion and the loss of adsorptive capacity. Isotherm tests on the regenerated carbon can be used to determine adsorptive capacity, thereby aiding in the prediction of the number of times the carbon can be regenerated.

(3) Waste characteristics affecting performance. The waste characteristics that will affect an activated carbon system's performance are as follows: (1) type of organic contaminants, (2) concentration of contaminants, and (3) suspended solids, grease and oil concentration.

At first, it might appear that pH and temperature would be significant factors that would affect adsorption. Polarity of some organic compounds is affected by pH, and polarity changes influence adsorption. Particularly with heavy metals, the activated carbon must have the proper pH to achieve satisfactory removal. Temperature becomes a significant factor when temperatures become high enough to desorb contaminants from activated carbon (usually over 100 C). However, these factors are considered to be easily controlled during the actual process and, as such, are not major hindrances to efficient adsorption.

(a) Type of organic contaminants. All organic molecules can be adsorbed by activated carbon to some degree. Generally, adsorption will increase with molecular weight until the particle size becomes too large for carbon pore size. However, the activated carbon usually has a greater affinity for aromatic compounds than for straight chain compounds. Nonpolar compounds are usually easily adsorbed, whereas polar ones are not. Halogenated organic compounds (HOCs), if aromatic (such as PCBs), are readily adsorbed. Finally, it has been demonstrated in practice that adsorption will increase with decreasing solubility.

For the carbon adsorption system, the WCAPs are the molecular weights of the constituents present. The molecular weights of the major constituents in the waste are as follows: 78.12 for benzene, 123.11 for nitrobenzene, 93.13 for aniline, 94.11 for phenol, and 184.11 for 2,4-dinitrophenol. The cyanides present are thought to be a mixture of complex organic and inorganic cyanide compounds, and therefore the molecular weight cannot be determined. Other important characteristics of the waste for the carbon adsorption unit are the total organic carbon content (which is 444 mg/l) and the total suspended solids content (which is 196 mg/l). The amount of oil and grease in the waste is not known.

(b) Concentration of contaminants. In actual practice this process becomes ineffective at concentrations exceeding a few thousand mg/l. The carbon will adsorb concentrated contaminants so fast that carbon consumption will become excessive, and frequent disposal and/or regeneration of carbon is likely to become a greater problem than removal of the organic materials from the waste stream. For excessively concentrated waste streams, other organic compound destruction techniques (e.g., incineration or reuse as a fuel) would probably be more appropriate.

(c) Suspended solids and grease and oil concentration. In powdered activated carbon (PAC) systems, suspended solids and grease concentrations in the wastewater stream have no effect, since they are removed from the waste along with the spent PAC. However, in nonfluidized granular activated carbon (GAC) systems (see Section (4)(b) for a description of these systems), the column of GAC acts as a filter for suspended particles and greases. It will eventually become plugged or bound with solids, or coated with grease and oils, and will not be able to sustain the flow of wastewater. Consequently, the more suspended solids or grease and oils in the GAC column influent, the sooner it must be backwashed, hence slowing the dissolved organic compound removal rate.

(4) Physical description of the process. Specific designs will depend on the waste stream to be treated and the type of end product desired. However, a few examples will provide some idea of how these systems work.

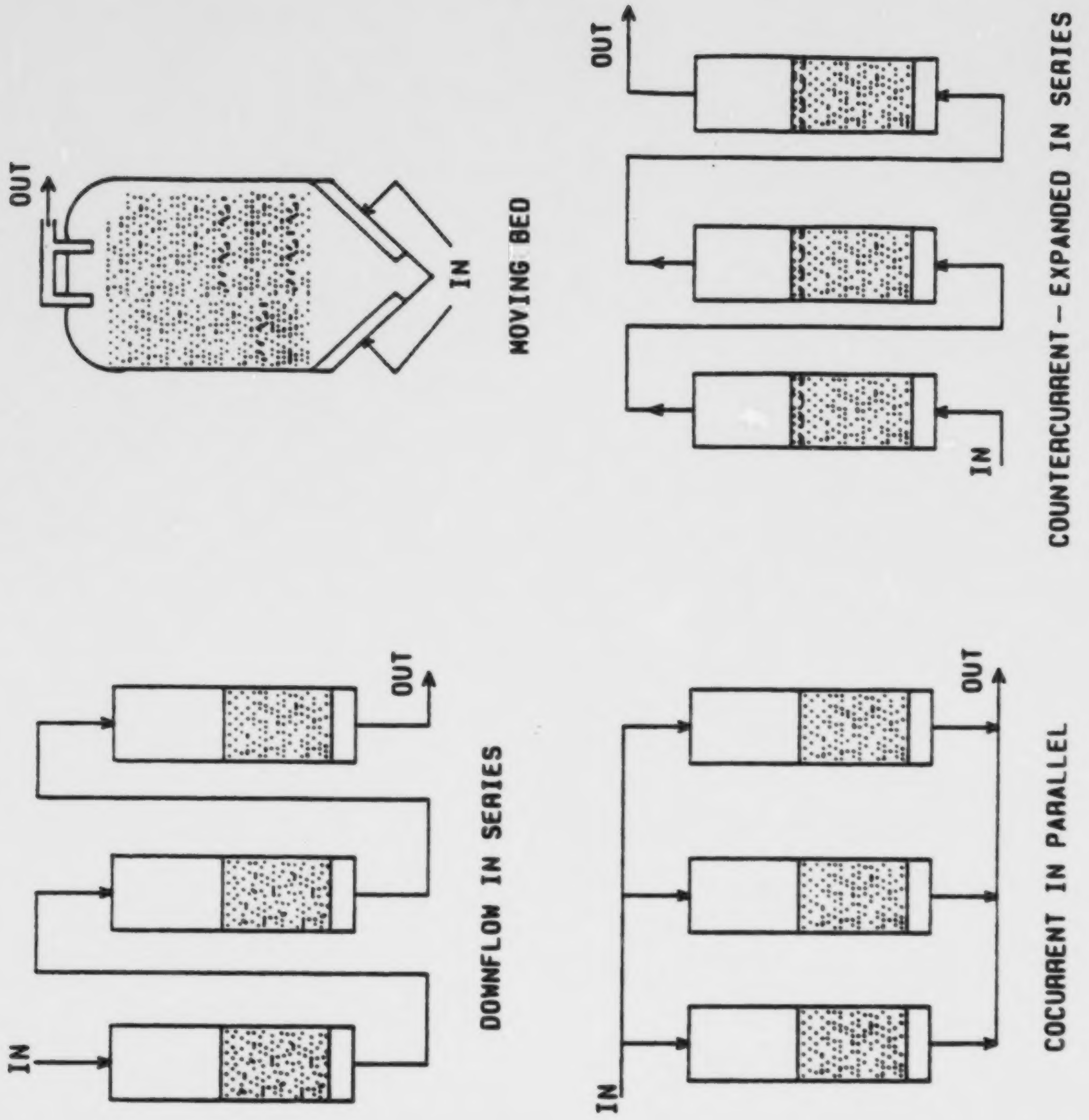
(a) Systems using PAC. PAC can be easily used in exiting **equipment** such as tanks, filtration, or settling apparatus. Since it is a fine powder, it is usually put directly into the waste stream. It needs lower contact times than GAC because it adsorbs contaminants more quickly. PAC usually has less adsorption capacity than GAC, so more is required. A few treatment systems are described below.

(i) Batch system. The incoming waste stream is thoroughly stirred with the PAC, usually with some type of mechanical agitator. The stirring time (contact time) is usually 20 to 30 minutes in most cases. After adsorption equilibrium is reached, the mixture is settled and/or filtered to separate the PAC from the wastewater. This procedure can be separated to increase filtrate clarity.

(ii) Continuous system. In a continuous system both the waste liquid and carbon slurry enter mixing tanks simultaneously and continuously. Continuous settling and/or filtration again follows the mixing.

(b) Systems using GAC. In GAC systems the carbon is packed in columns and the liquid is passed through a bed of the carbon. The liquid flow can be either up or down through the vertical column. Figure 3-4 shows some common systems.

Typically, the wastewater to be treated is passed downward through a stationary bed of carbon. The constituent to be removed is adsorbed most rapidly and effectively by the upper few layers of fresh carbon during the initial stages of operation. These upper layers are in contact with the wastewater at its highest concentration level. The small amounts of target constituent that escape adsorption in the first few layers of the activated carbon are removed from solution in


OUT
IN
MOVING BED
OUT
IN
COUNTERCURRENT – EXPANDED IN SERIES
IN
OUT
DOWNFLOW IN SERIES
IN
OUT
COCURRENT IN PARALLEL

SOURCE: RIZZO AND SHEPHARD 1987

Figure 3-4 TYPICAL COLUMN CONFIGURATIONS

the lower or downstream portion of the bed. Initially, none of the constituent to be removed escapes from the adsorbent.

As the liquid flows down the column, the adsorption capacity is reached in the top layers and the adsorption zone starts moving down the column. As the adsorption zone moves near the end of the bed, the concentration in the effluent rapidly approaches the influent concentration. This point in the operation is referred to as breakthrough. A breakthrough curve (Figure 3-5) is the plot of the ratio of effluent to influent concentrations versus time of operation. At breakthrough the bed is exhausted and little additional removal of the constituent will occur. At this point, the carbon must be replaced or regenerated.

(5) Design and operating parameters.

(a) Design parameters. The system design must account for three parameters that affect the ability of activated carbon to adsorb contaminants: (1) contact time, (2) carbon particle type and size, and (3) wastewater flow rate.

(i) Contact time. For both PAC and GAC systems, contact time must be determined by testing individual wastes with different activated carbon samples. Once contact time is determined for adequate removal of contaminants, tank sizing is the next step and it will depend on waste flow rate.

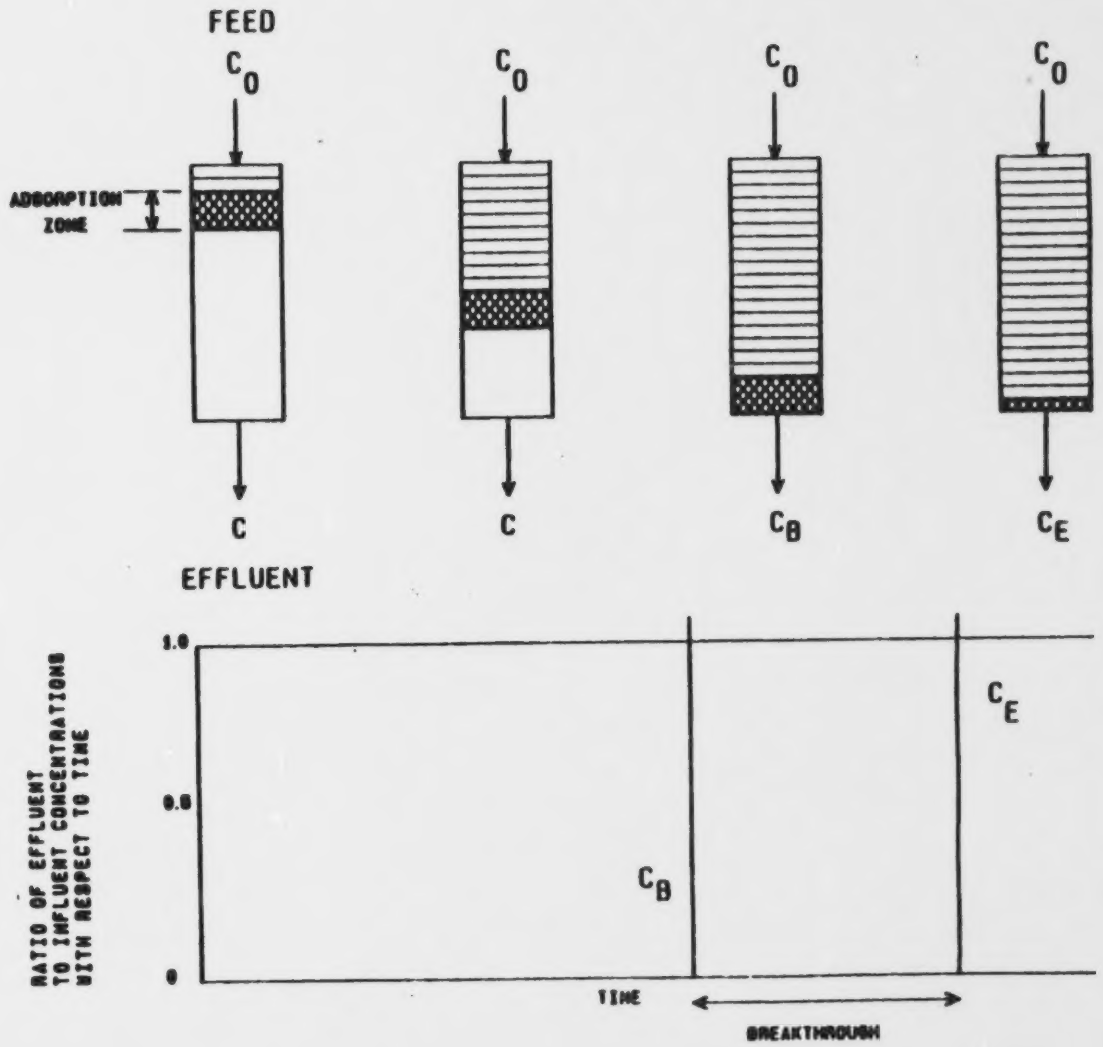

FEED
C_0
ADSORPTION ZONE
C
EFFLUENT
C_0
C
C_0
C_B
C_0
C_E
RATIO OF EFFLUENT TO INFLUENT CONCENTRATIONS WITH RESPECT TO TIME
1.0
0.5
0
C_B
C_E
TIME
BREAKTHROUGH

Figure 3-5 PLOT OF BREAKTHROUGH CURVE

SOURCE: USEPA 1986

(ii) Carbon particle type and size. Activated carbon is made from a variety of substances (e.g., coal, wood), ground to many different sizes, and manufactured with "customized" pore sizes. A range of surface areas and individual pore sizes will determine the carbon's adsorptive capacity. Bench testing is recommended to determine the most effective activated carbon product for a particular waste stream and desired effluent.

(iii) Wastewater flow rate. GAC systems are designed for upflow or downflow operation. For both types, there are practical limits to the liquid velocity. Once the velocity and contact time are determined, the bed cross-section and depth are sized to meet these requirements.

(b) Operating parameters. A number of parameters must be maintained during operation to ensure that the adsorption system adheres to the design specifications. These are: (1) waste liquid concentration, (2) suspended oils and solids, and (3) contact time.

(i) Waste liquid concentration. In GAC systems, the concentration has a direct effect on the operation of an adsorption system because if the concentration is significantly higher than the design concentration, column breakthrough will occur quickly and excessive regeneration will be required. Conversely, if, during the operation of a column, the waste liquid concentration decreases significantly, previously adsorbed molecules can be desorbed from the carbon and discharged in the effluent stream. Additionally, changes in the waste composition can cause previously adsorbed molecules to be desorbed and replaced by molecules of a different constituent if the new constituent has a higher affinity for the carbon surface. These types of situations can lead to effluent concentrations for a particular waste constituent that are higher than influent concentrations. Waste liquid concentration has a lesser effect on PAC systems because the PAC is removed as it is spent. Desorption is not a problem. However, if the concentration increases significantly over the design concentrations, excessive quantities of PAC may be required. In any case, the effluent must be monitored for breakthrough of contaminants.

(ii) Suspended oils and solids. Suspended oils and solids are not usually a problem with PAC systems. However, in GAC systems, oils and suspended solids in the waste will eventually plug the column. If the concentration of solids is significant (typically greater than 200 mg/l), the waste will need to be pretreated to remove them. In any case, suspended solids and greases present in the GAC column influent will necessitate backwashing and/or column cleaning. The need for such cleaning can be detected with pressure gauges that monitor the degree of plugging.

(iii) Contact time. Contact time requirements vary with the type of system but must be maintained within design specifications. Typical contact times vary between 100 and 300 minutes for GAC systems, and are somewhat lower for PAC systems. For GAC systems, typical downflow rates are between 20 and 330 l/min m^2 of bed area. A typical upflow rate is 610 l/min m^2 of bed area, unless the bed is fluidized, in which case higher velocities are necessary. Contact time is monitored by measuring wastewater flow rate, since system volume is predetermined.

3.2.4 Incineration

This section addresses the commonly used incineration technologies: liquid injection, rotary kiln, fluidized bed, and fixed hearth. A discussion is provided regarding the applicability of these technologies, the underlying principles of operation, a technology description, waste characteristics that affect performance, and finally important design and operating parameters. As appropriate, the subsections are divided by type of incineration unit.

(1) Applicability and use of incineration.

(a) Liquid injection. Liquid injection is applicable to wastes that have viscosity values sufficiently low so that the waste can be atomized in the combustion chamber. A range of literature maximum viscosity values are reported, with the low being 100 SSU and the high being 10,000 SSU. It is important to note that viscosity is temperature dependent so that while liquid injection may not be applicable to a waste at ambient conditions, it may be applicable when the waste is heated. Other factors that affect the use of liquid injection are particle size and the presence of suspended solids. Both of these waste parameters can cause plugging of the burner nozzle.

(b) Rotary kiln/fluidized bed/fixed hearth. These incineration technologies are applicable to a wide range of hazardous wastes. They can be used on wastes that contain high or low total organic content, high or low filterable solids, various viscosity ranges, and a range of other waste parameters. EPA has not found these technologies to be demonstrated on wastes that are composed essentially of metals with low organic concentrations. In addition, the Agency expects that some of the high metal content wastes may not be compatible with existing and future air emission limits without emission controls far more extensive than those currently used.

(2) Underlying principles of operation.

(a) Liquid injection. The basic operating principle of this incineration technology is that incoming liquid wastes are volatilized and then additional heat is supplied to the waste to destabilize the chemical bonds. Once the chemical bonds are broken, these constituents react with oxygen to form carbon dioxide and water vapor. The energy needed to destabilize the bonds is referred to as the energy of activation.

(b) Rotary kiln and fixed hearth. There are two distinct principles of operation for these incineration technologies, one for each of the chambers involved. In the primary chamber, energy, in the form of heat, is transferred to the waste to achieve volatilization of the various organic waste constituents. During this volatilization process some of the organic constituents will oxidize to carbon dioxide and water vapor. In the secondary chamber, additional heat is supplied to overcome the energy requirements needed to destabilize the chemical bonds and allow the constituents to react with excess oxygen to form carbon dioxide and water vapor. The principle of operation for the secondary chamber is similar to liquid injection.

(c) Fluidized bed. The principle of operation for this incineration technology is somewhat different from that for rotary kiln and fixed hearth incineration relative to the functions of the primary and secondary chambers. In fluidized bed incineration, the purpose of the primary chamber is not only to volatilize the wastes but also to essentially combust the waste. Destruction of the waste organics can be accomplished to a better degree in the primary chamber of the fluidized bed than in that of the rotary kiln or fixed hearth because of (1) improved heat transfer from fluidization of the waste using forced air and (2) the fact that the fluidization process provides sufficient oxygen and turbulence to convert the organics to carbon dioxide and water vapor. The secondary chamber (referred to as the freeboard) generally does not have an afterburner; however, additional time is provided for conversion of the organic constituents to carbon dioxide, water vapor, and hydrochloric acid if chlorine is present in the waste.

(3) Description of incineration technologies.

(a) Liquid injection. The liquid injection system is capable of incinerating a wide range of gases and liquids. The combustion system has a simple design with virtually no moving parts. A burner or nozzle atomizes the liquid waste and injects it into the combustion chamber, where it burns in the presence of air or oxygen. A forced draft system supplies the combustion chamber with air to provide oxygen for combustion and turbulence for mixing. The combustion chamber is usually a cylinder lined with refractory (i.e., heat-resistant) brick and can be fired horizontally, vertically upward, or vertically downward. Figure 3-6 illustrates a liquid injection incineration system.

(b) Rotary kiln. A rotary kiln is a slowly rotating, refractory-lined cylinder that is mounted at a slight incline from the horizontal (see Figure 3-7). Solid wastes enter at the high end of the kiln, and liquid or gaseous wastes enter through atomizing nozzles in the kiln or afterburner section. Rotation of the kiln exposes the solids to the heat, vaporizes them, and allows them to combust by mixing with air. The rotation also causes the ash to move to the lower end of the kiln, where it can be removed. Rotary kiln systems usually have a secondary combustion chamber or afterburner following the kiln for further combustion of the volatilized components of solid wastes.

(c) Fluidized bed. A fluidized bed incinerator consists of a column containing inert particles such as sand which is referred to as the bed. Air, driven by a blower, enters the bottom of the bed to fluidize the sand. Air passage through the bed promotes rapid and uniform mixing of the injected waste material within the fluidized bed. The fluidized bed has an extremely high heat capacity (approximately three times that of flue gas at the same temperature), providing a large heat reservoir. The injected waste reaches ignition

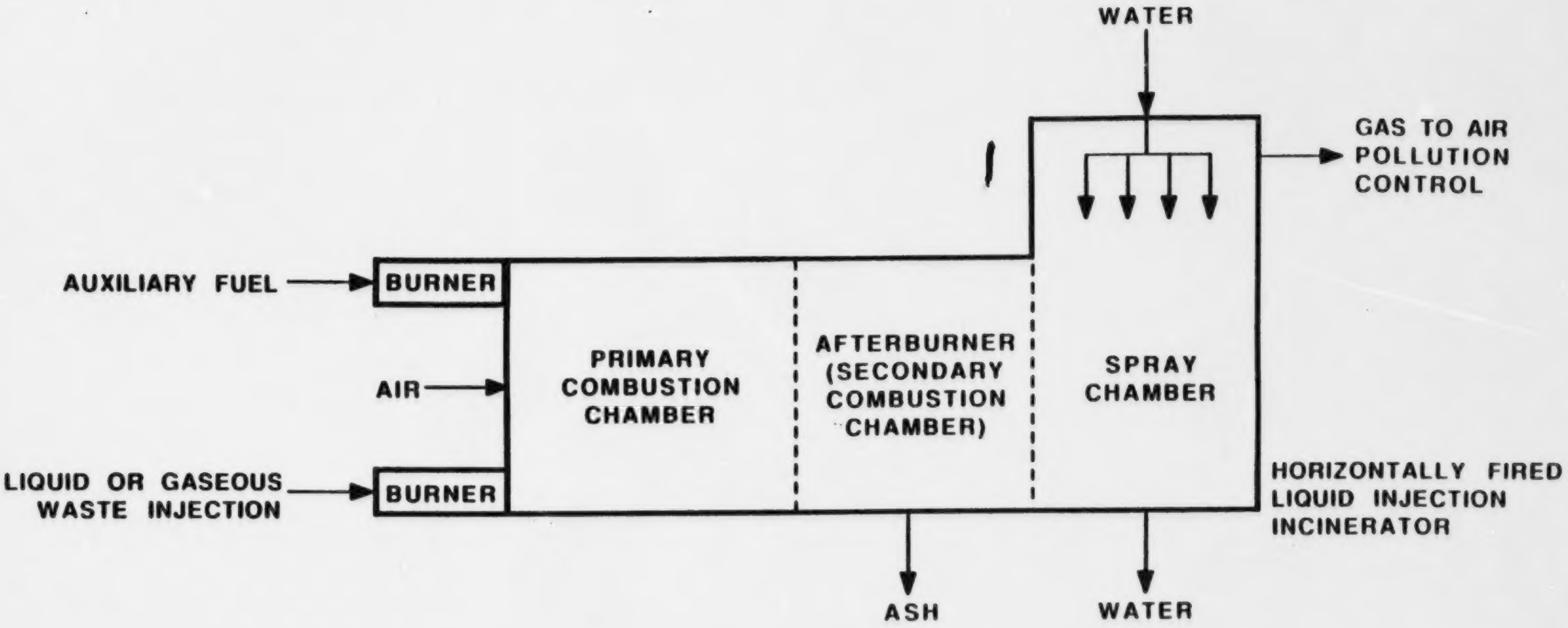

WATER
GAS TO AIR POLLUTION CONTROL
AUXILIARY FUEL
BURNER
AIR
PRIMARY COMBUSTION CHAMBER
AFTERBURNER (SECONDARY COMBUSTION CHAMBER)
SPRAY CHAMBER
LIQUID OR GASEOUS WASTE INJECTION
BURNER
HORIZONTALLY FIRED LIQUID INJECTION INCINERATOR
ASH
WATER

Figure 3-6

LIQUID INJECTION INCINERATOR

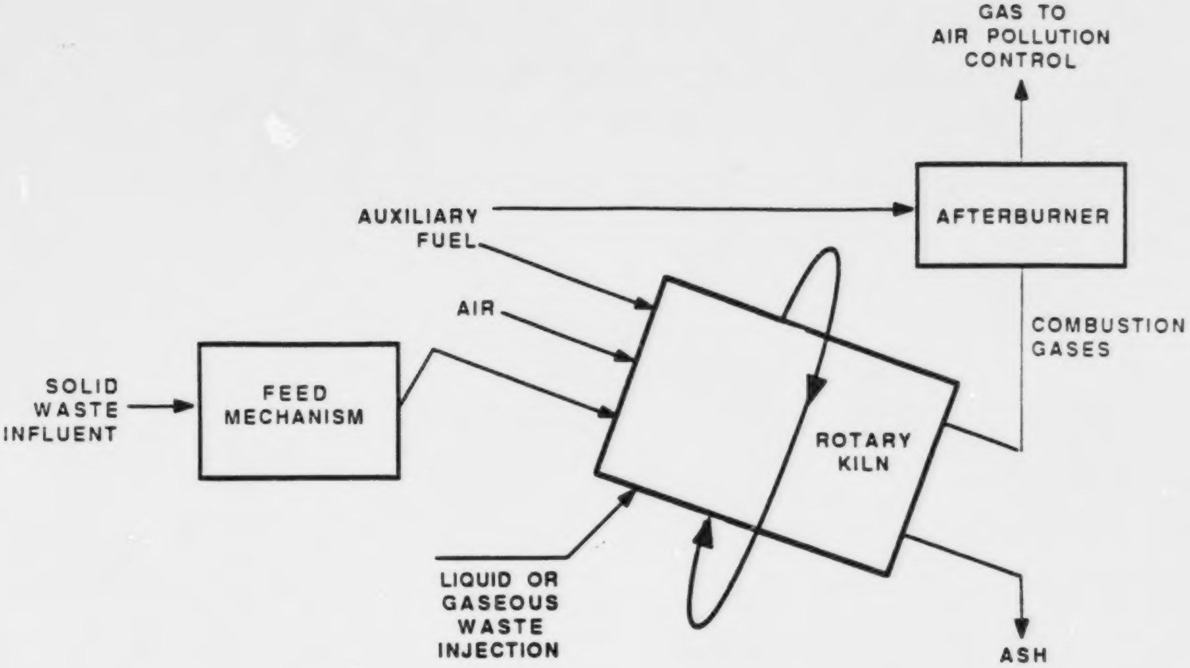

GAS TO AIR POLLUTION CONTROL
AUXILIARY FUEL
AFTERBURNER
AIR
COMBUSTION GASES
SOLID WASTE INFLUENT
FEED MECHANISM
ROTARY KILN
LIQUID OR GASEOUS WASTE INJECTION
ASH

Figure 3-7
ROTARY KILN INCINERATOR

temperature quickly and transfers the heat of combustion back to the bed. Continued bed agitation by the fluidizing air allows larger particles to remain suspended in the combustion zone. (See Figure 3-8).

(d) Fixed hearth incineration. Fixed hearth incinerators, also called controlled air or starved air incinerators, are another major technology used for hazardous waste incineration. Fixed hearth incineration is a two-stage combustion process (see Figure 3-9). Waste is ram-fed into the first stage, or primary chamber, and burned at less than stoichiometric conditions. The resultant smoke and pyrolysis products, consisting primarily of volatile hydrocarbons and carbon monoxide, along with the normal products of combustion, pass to the secondary chamber. Here, additional air is injected to complete the combustion. This two-stage process generally yields low stack particulate and carbon monoxide (CO) emissions. The primary chamber combustion reactions and combustion gas are maintained at low levels by the starved air conditions so that particulate entrainment and carryover are minimized.

(e) Air pollution controls. Following incineration of hazardous wastes, combustion gases are generally further treated in an air pollution control system. The presence of chlorine or other halogens in the waste requires a scrubbing or absorption step to remove HCl and other halo-acids from the combustion gases. Ash in the waste is not destroyed in the combustion process. Depending on its composition, ash will exit either as bottom ash, at the discharge end of a kiln or hearth for example, or as particulate matter (fly ash) suspended in the

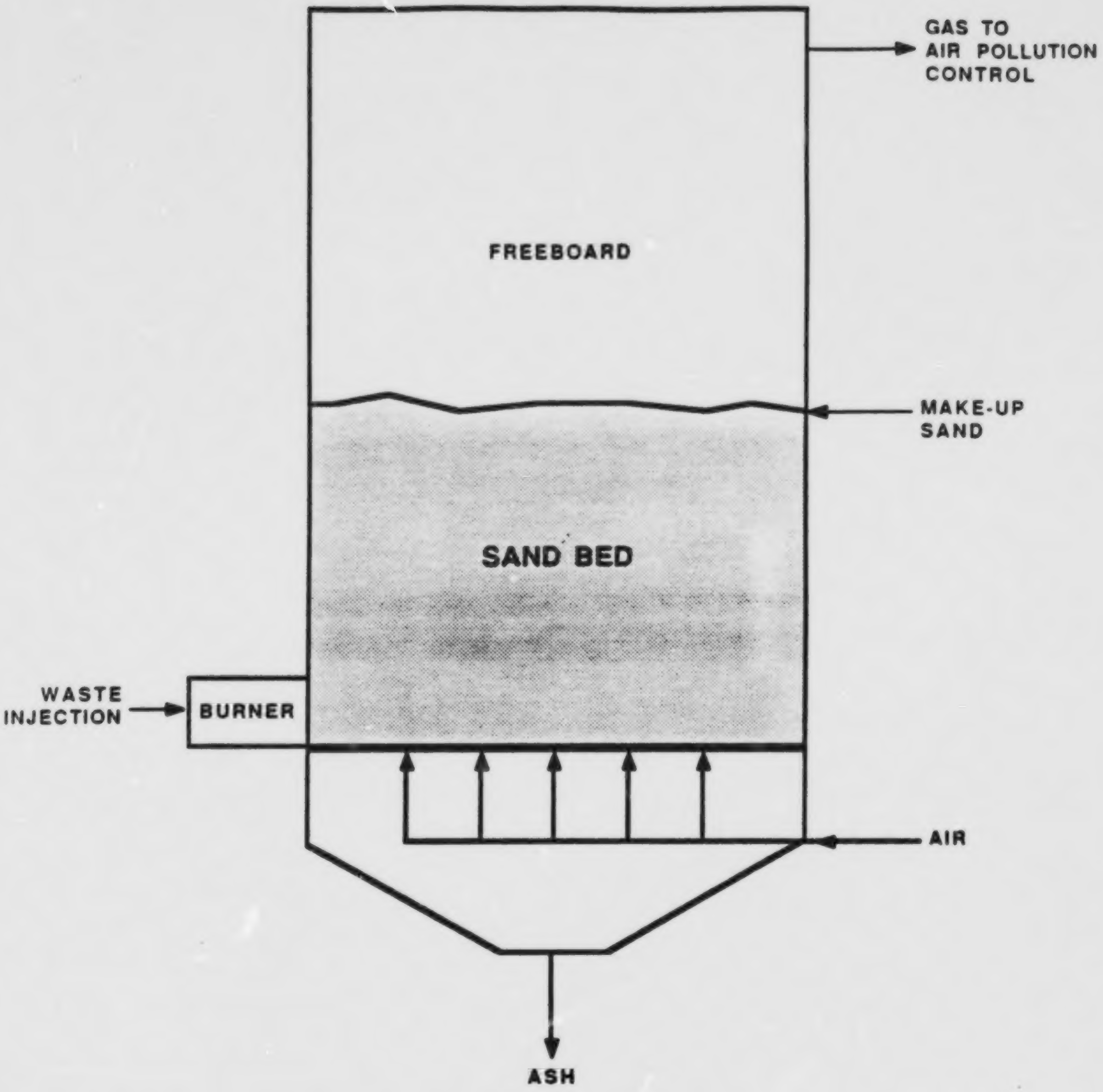

GAS TO
AIR POLLUTION
CONTROL
FREEBOARD
MAKE-UP
SAND
SAND BED
WASTE
INJECTION
BURNER
AIR
ASH

Figure 3-8
FLUIDIZED BED INCINERATOR

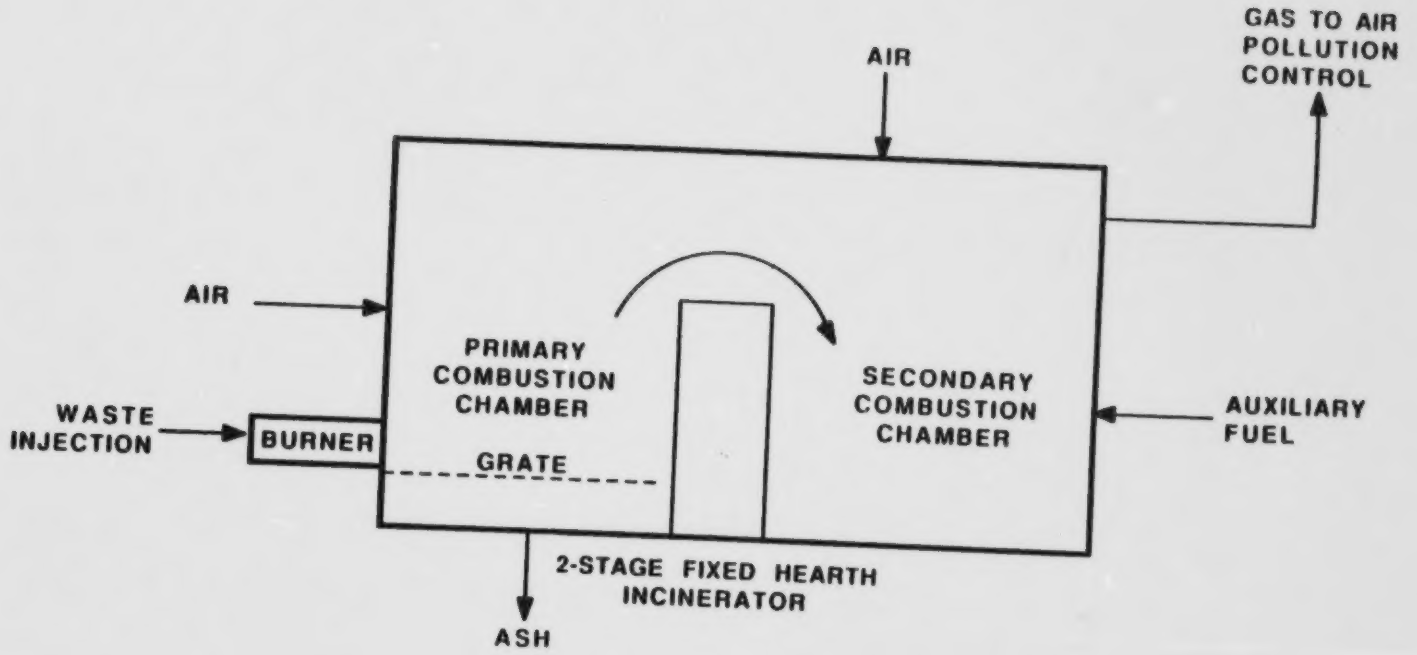

GAS TO AIR
POLLUTION
CONTROL
AIR
AIR
PRIMARY
COMBUSTION
CHAMBER
SECONDARY
COMBUSTION
CHAMBER
WASTE
INJECTION
BURNER
GRATE
AUXILIARY
FUEL
2-STAGE FIXED HEARTH
INCINERATOR
ASH

Figure 3-9
FIXED HEARTH INCINERATOR

combustion gas stream. Particulate emissions from most hazardous waste combustion systems generally have particle diameters of less than 1 micron and require high-efficiency collection devices to minimize air emissions. In addition, scrubber systems provide an additional buffer against accidental releases of incompletely destroyed waste products resulting from poor combustion efficiency or combustion upsets, such as flame-outs.

(4) Waste characteristics affecting performance.

(a) Liquid injection. In determining whether liquid injection is likely to achieve the same level of performance on an untested waste as on a previously tested waste, the Agency will compare dissociation bond energies of the constituents in the untested and tested waste. This parameter is being used as a surrogate indicator of activation energy, which, as discussed previously, destabilizes molecular bonds. In theory, the bond dissociation energy would be equal to the activation energy; however, in practice this is not always the case. Other energy effects (e.g., vibrational effects, the formation of intermediates, and interactions between different molecular bonds) may have a significant influence on activation energy.

Because of the shortcomings of bond energies in estimating activation energy, EPA analyzed other waste characteristic parameters to determine whether these parameters would provide a better basis for transferring treatment standards from an untested waste to a tested waste. These parameters include heat of combustion, heat of formation, use of available kinetic data to predict activation energies, and general structural class. All of these were rejected for the reasons provided below.

The heat of combustion measures only the difference in energy of the products and reactants: it does not provide information on the transition state (i.e., the energy input needed to initiate the reaction). Heat of formation is used as a predictive tool for whether reactions are likely to proceed; however, there are a significant number of hazardous constituents for which these data are not available. Use of kinetic data was rejected because these data are limited and could not be used to calculate free energy values (ΔG) for the wide range of hazardous constituents to be addressed by this rule. Finally, EPA decided not to use structural classes because the Agency believes that evaluation of bond dissociation energies allows for a more direct determination of whether a constituent will be destabilized.

(b) Rotary kiln/fluidized bed/fixed hearth. Unlike liquid injection, these incineration technologies also generate a residual ash. Accordingly, in determining whether these technologies are likely to achieve the same level of performance on an untested waste as on a previously tested waste, EPA examines the waste characteristics that affect volatilization of organics from the waste, as well as destruction of the organics once volatilized. Relative to volatilization, EPA examines thermal conductivity of the entire waste and boiling point of the various constituents. As with liquid injection, EPA examines bond energies in determining whether treatment standards for scrubber water residuals can be transferred from a tested waste to an untested waste. Below is a discussion of how EPA arrived at thermal conductivity and boiling point as the best method to assess volatilization of organics from the waste; the discussion relative to bond energies is the same for these technologies as for liquid injection and will not be repeated here.

(i) Thermal conductivity. Consistent with the underlying principles of incineration, a major factor with regard to whether a particular constituent will volatilize is the transfer of heat through the waste. In the case of rotary kiln, fluidized bed, and fixed hearth incineration, heat is transferred through the waste by three mechanisms: radiation, convection, and conduction. For a given incinerator, heat transferred through various wastes by radiation is more a function of the design and type of incinerator than of the waste being treated. Accordingly, the type of waste treated will have a minimal impact on the amount of heat transferred by radiation. With regard to convection, EPA also believes that the type of heat transfer will generally be more a function of the type and design of incinerator than of the waste itself. However, EPA is examining particle size as a waste characteristic that may significantly impact the amount of heat transferred to a waste by convection and thus impact volatilization of the various organic compounds. The final type of heat transfer, conduction, is the one that EPA believes will have the greatest impact on volatilization of organic constituents. To measure this characteristic, EPA will use thermal conductivity; an explanation of this parameter, as well as how it can be measured, is provided below.

Heat flow by conduction is proportional to the temperature gradient across the material. The proportionality constant is a property of the material and is referred to as the thermal conductivity. (Note: The analytical method that EPA has identified for measurement of thermal conductivity is named "Guarded, Comparative, Longitudinal Heat Flow Technique"; it is described in Appendix F.) In theory, thermal conductivity would always provide a good indication of whether a constituent in an untested waste would be treated to the same extent in the primary incinerator chamber as the same constituent in a previously tested waste.

In practice, thermal conductivity has some limitations in assessing the transferability of treatment standards; however, EPA has not identified a parameter that can provide a better indication of heat transfer characteristics of a waste. Below is a discussion of the limitations associated with thermal conductivity, as well as other parameters considered.

Thermal conductivity measurements, as part of a treatability comparison for two different wastes through a single incinerator, are most meaningful when applied to wastes that are homogeneous (i.e., major constituents are essentially the same). As wastes exhibit greater degrees of nonhomogeneity (e.g., significant concentration of metals in soil), thermal conductivity becomes less accurate in predicting treatability because the measurement essentially reflects heat flow through regions having the greatest conductivity (i.e., the path of least resistance) and not heat flow through all parts of the waste.

BTU value, specific heat, and ash content were also considered for predicting heat transfer characteristics. These parameters can no better account for nonhomogeneity than can thermal conductivity; additionally, they are not directly related to heat transfer characteristics. Therefore, these parameters do not provide a better indication of heat transfer that will occur in any specific waste.

(ii) Boiling point. Once heat is transferred to a constituent within a waste, removal of this constituent from the waste will depend on its volatility. EPA is using boiling point of the constituent as a surrogate of volatility. Compounds with lower boiling points have higher vapor pressures and, therefore, would be more likely to vaporize. The Agency recognizes that this parameter does not take into consideration the impact of other compounds in the waste on the boiling point of a constituent in a mixture; however, the Agency is not aware of a better measure of volatility that can easily be determined.

(5) Incineration design and operating parameters.

(a) Liquid injection. For a liquid injection unit, EPA's analysis of whether the unit is well designed focuses on (1) the likelihood that sufficient energy is provided to the waste to overcome the activation level for breaking molecular bonds and (2) whether sufficient oxygen is present to convert the waste constituents to carbon dioxide and water vapor. The specific design parameters that the Agency will evaluate to assess whether these conditions are met are temperature, excess oxygen, and residence time. Below is a discussion of why EPA believes these parameters to be important, as well as a discussion of how these parameters should be monitored during operation.

It is important to point out that, relative to the development of land disposal restriction standards, EPA is concerned with these design parameters only when a quench water or scrubber water residual is generated from treatment of a particular waste. If treatment of a particular waste in a liquid injection unit would not generate a wastewater stream, then the Agency, for purposes of land disposal treatment standards, would be concerned with only the waste characteristics that affect selection of the unit, not the above-mentioned design parameters.

(i) Temperature. Temperature is important in that it provides an indirect measure of the energy available (i.e., Btu/hr) to overcome the activation energy of waste constituents. As the design temperature increases, it becomes more likely that the molecular bonds will be destabilized and the reaction completed.

The temperature is normally controlled automatically through the use of instrumentation that senses the temperature and automatically adjusts the amount of fuel and/or waste being fed. The temperature signal transmitted to the controller can be simultaneously transmitted to a recording device, referred to as a strip chart, and thereby continuously recorded. To fully assess the operation of the unit, it is important to know not only the exact location in the incinerator at which the temperature is being monitored but also the location of the design temperature.

(ii) Excess oxygen. It is important that the incinerator contain oxygen in excess of the stoichiometric amount necessary to convert the organic compounds to carbon dioxide and water vapor. If insufficient oxygen is present, then destabilized waste constituents could recombine to the same or other BDAT list organic compounds and potentially cause the scrubber water to contain higher concentrations of BDAT list constituents than would be the case for a well-operated unit.

In practice, the amount of oxygen fed to the incinerator is controlled by continuous sampling and analysis of the stack gas. If the amount of oxygen drops below the design value, then the analyzer transmits a signal to the valve controlling the air supply, thereby increasing the flow of oxygen to the afterburner. The analyzer simultaneously transmits a signal to a recording device so that the amount of excess oxygen can be continuously recorded. Again, as with temperature, it is important to know the location from which the combustion gas is being sampled.

(iii) Carbon monoxide. Carbon monoxide is an important operating parameter because it provides an indication of the extent to which the waste organic constituents are being converted to carbon dioxide water vapor. An increase in carbon monoxide level indicates that greater amounts of organic waste constituents are unreacted or partially reacted. Increased carbon monoxide levels can result from insufficient excess oxygen, insufficient turbulence in the combustion zone, or insufficient residence time.

(iv) Waste feed rate. The waste feed rate is important to monitor because it is correlated to the residence time. The residence time is associated with a specific Btu energy value of the feed and a specific volume of combustion gas generated. Prior to incineration, the Btu value of the waste is determined through the use of a laboratory device known as a bomb calorimeter. The volume of combustion gas generated from the waste to be incinerated is determined from an analysis referred to as an ultimate analysis. This analysis determines the amount of elemental constituents present, which include carbon, hydrogen, sulfur, oxygen, nitrogen, and halogens. Using this analysis plus the total amount of air added, one can calculate the volume of combustion gas. After both the Btu content and the expected combustion gas volume have been determined, the feed rate can be fixed at the desired residence time. Continuous monitoring of the feed rate will determine whether the unit was operated at a rate corresponding to the designed residence time.

(b) Rotary kiln. For this form of incineration, EPA examines both the primary and secondary chambers in evaluating the design of a particular incinerator. Relative to the primary chamber, EPA's assessment of design will focus on whether it is likely that sufficient energy will be provided to the waste to volatilize the waste constituents. For the secondary chamber, analogous to the sole liquid injection incineration chamber, EPA will examine the same parameters discussed previously under liquid injection incineration. These parameters will not be discussed again here.

The specific design parameters evaluated for the primary chamber are kiln temperature, residence time, and revolutions per minute. Below is a discussion of why EPA believes these parameters to be important, as well as a discussion of how these parameters will be monitored during operation.

(i) Temperature. The primary chamber temperature is important, in that it provides an indirect measure of the energy input (i.e., Btu/hr) that is available for heating the waste. The higher the temperature in a given kiln, the more likely it is that the constituents will volatilize. As discussed earlier under "Liquid injection," temperature should be continuously monitored and recorded. Additionally, it is important to know the location of the temperature sensing device in the kiln.

(ii) Residence time. This parameter is important in that it affects whether sufficient heat is transferred to a particular constituent for volatilization to occur. As the time that the waste is in the kiln is increased, a greater quantity of heat is transferred to the hazardous waste constituents. The residence time will be a function of the specific configuration of the rotary kiln, including the length and diameter of the kiln, the waste feed rate, and the rate of rotation.

(iii) Revolutions per minute (RPM). This parameter provides an indication of the turbulence that occurs in the primary chamber of a rotary kiln. As the turbulence increases, the quantity of heat transferred to the waste would also be expected to increase. However, as the RPM value increases, the residence time decreases resulting in a reduction of the quantity of heat transferred to the waste. This parameter needs to be carefully evaluated because it provides a balance between turbulence and residence time.

(c) Fluidized bed. As discussed previously, in the section on "Underlying principles of operation," the primary chamber accounts for almost all of the conversion of organic wastes to carbon dioxide, water vapor, and acid gas if halogens are present. The secondary chamber will generally provide additional residence time for thermal oxidation of the waste constituents. Relative to the primary chamber, the parameters that the Agency examines in assessing the effectiveness of the design are temperature, residence time, and bed pressure differential. The first two were discussed under rotary kiln and will not be repeated here. The third, bed pressure differential, is important in that it provides an indication of the amount of turbulence and, therefore, indirectly the amount of heat supplied to the waste. In general, as the pressure drop increases, both the turbulence and heat supplied increase. The pressure drop through the bed should be continuously monitored and recorded to ensure that the designed valued is achieved.

(d) Fixed hearth. The design considerations for this incineration unit are similar to those for a rotary kiln with the exception that rate of rotation (i.e., RPM) is not an applicable design parameter. For the primary chamber of this unit, the parameters that the

Agency will examine in assessing how well the unit is designed are the same as those discussed under rotary kiln; for the secondary chamber (i.e., afterburner), the design and operating parameters of concern are the same as those previously discussed under "Liquid Injection."

4. PERFORMANCE DATA BASE

This section discusses all available performance data that EPA has on the demonstrated technologies discussed in Section 3. Performance data include the untreated and treated waste concentrations for a given constituent, the operating values that existed at the time the waste was being treated, the design values for the treatment technology, and data on waste characteristics that affect treatment performance. EPA has provided all such data to the extent that they are available.

EPA's use of these data in determining the technology that represents BDAT and in the development of treatment standards is discussed in Sections 5 and 7, respectively. For K103 and K104 wastewaters, EPA has performance data on liquid/liquid extraction followed by steam stripping and activated carbon adsorption.

Performance data collected by EPA for liquid/liquid extraction followed by stream stripping and carbon adsorption are presented in Tables 4-1 to 4-5 at the end of this section. Tables 4-1 through 4-5 present the analytical data for sample sets 1 through 5 collected during the Agency's sampling visit. The untreated K103 and K104 wastes and the combined treated stream leaving the carbon adsorption beds for each sample set were analyzed for BDAT volatile and semivolatile organic compounds, metals, inorganic compounds, and other parameters.

Included in Tables 4-1 through 4-5 are the design values and actual operating ranges for the key operating parameters of the aniline liquid/liquid extractor, nitrobenzene liquid/liquid extractor, steam stripper, and activated carbon adsorption beds for each sample set collected.

Additional performance data for K103 and K104 wastewaters were extracted from the Organic Chemicals, Plastics and Synthetic Fibers Data Base for the aniline and nitrobenzene industry. The treatment system used was either steam stripping or steam stripping followed by activated carbon adsorption. Table 4-6 presents the composite analytical data for nitrobenzene and 2,4-dinitrophenol. The specific treatment system is footnoted on Table 4-6. Design and operating ranges were not submitted by Facility 500P. The design and operating ranges for Facility 2680T have been claimed as RCRA Confidential Business Information. The design and operating data are available in the confidential portion of the Administrative Record for this rulemaking.

EPA does not have performance data from rotary kiln incineration specifically for K103 and K104 nonwastewaters. Six sample sets from the treatment of K019 were collected by the Agency for rotary kiln incineration. The six data sets were transferred* to the resulting K103 and K104 nonwastewaters based on waste characteristics affecting performance. None of the data sets in K019 were deleted because of poor design or operation of the treatment system during the time data were being collected.

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* See Section 7.4 for a discussion on how the data were transferred.

Six sample sets from the treatment of K048-K052 by incineration were also collected by the Agency. These performance data sets for cyanide (total) were transferred to K103 and K104 nonwastewaters.

Tables 4-7 through 4-12 represent treatment performance data collected by EPA for K019 at Plant A for rotary kiln incineration. Design values are claimed as RCRA Confidential Business Information. Design values are available in the confidential portion of the Administrative Record for this rulemaking. Tables 4-13 through 4-18 represent treatment performance data collected by EPA for K048 and K051 at Plant A for fluidized bed incineration. Included in Tables 4-13 through 4-18 are the design values and actual operating ranges for the key operating parameters of the fluidized bed incineration for each sample set collected.

TABLE 4-1 TREATMENT DATA FOR SAMPLE SET 1 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION

BDAT CONSTITUENTS DETECTED	UNTREATED WASTE K103 (mg/l)	UNTREATED WASTE K104 (mg/l)	TREATED WASTE K103 (mg/l)	TREATED WASTE K104 (mg/l)
Volatile Organic Compounds				
4 Benzene	81	240	2.8	45
48 Trichloromonofluoromethane	<2.5	<10	<0.5	<0.5
Semivolatile Organic Compounds				
56 Aniline	51,000	<150	<60	<75
101 2,4-Dinitrophenol	<7,500	<750	<300	<375
126 Nitrobenzene	<1,500	2,700	2,300	2,800
142 Phenol	<1,500	<150	<60	<75
Metals				
155 Arsenic	<0.010	<0.010	NA	NA
156 Barium	<0.001	0.0078	NA	NA
159 Chromium	<0.007	0.432	NA	NA
160 Copper	<0.006	0.012	NA	NA
161 Lead	<0.005	<0.050	NA	NA
163 Nickel	<0.011	0.238	NA	NA
167 Vanadium	<0.006	<0.006	NA	NA
168 Zinc	0.021	0.079	NA	NA
Inorganics				
169 Total Cyanides	0.0748	6.28	NA	NA
170 Fluorides	<0.20	<0.20	NA	NA
171 Sulfides	89.0	<1.0*	NA	NA

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a - Onsite Engineering Report for E.I. Dupont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14

NA - Not Analyzed

* - Less than detection limit -- caused by interference

TABLE 4-1 (continued) TREATMENT DATA FOR SAMPLE SET 1 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING

		UNTREATED WASTE		TREATED WASTE
		K103	K104	
	BDAT CONSTITUENTS DETECTED	(mg/l)		(mg/l)
	Volatile Organic Compounds			
4	Benzene	81	240	<0.005
48	Trichloromonofluoromethane	<2.5	<10	0.010
	Semivolatile Organic Compounds			
56	Aniline	51,000	<150	<3
101	2,4-Dinitrophenol	<7,500	<750	57
126	Nitrobenzene	<1,500	2,700	<3
127	4-Nitrophenol	<7,500	<750	<15
142	Phenol	<1,500	<150	<3
**	Benzoic Acid	<7,500	<750	15
	Metals			
155	Arsenic	<0.010	<0.010	NA
156	Barium	<0.001	0.0078	NA
159	Chromium	<0.007	0.432	NA
160	Copper	<0.006	0.012	NA
161	Lead	<0.005	<0.050	NA
163	Nickel	<0.011	0.238	NA
167	Vanadium	<0.006	<0.006	NA
168	Zinc	0.021	0.079	NA
	Inorganics			
169	Total Cyanides	0.0748	6.28	4.77
170	Fluorides	<0.20	<0.20	NA
171	Sulfides	89.0	<1.0*	<1.0*

a - Onsite Engineering Report for E.I. Dupont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14

NA - Not Analyzed

* - Less than detection limit -- caused by interference

** - Not on BDAT list of constituents

TABLE 4-1 (continued) TREATMENT DATA FOR SAMPLE SET 1 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING AND ACTIVATED CARBON ADSORPTION

		UNTREATED WASTE		TREATED WASTE
BDAT CONSTITUENTS DETECTED		K103 (mg/l)	K104 (mg/l)	(mg/l)
	Volatile Organic Compounds			
4	Benzene	81	240	0.042
48	Trichloromonofluoromethane	<2.5	<10	0.007
	Semivolatile Organic Compounds			
56	Aniline	51,000	<150	<0.030
101	2,4-Dinitrophenol	<7,500	<750	0.380
126	Nitrobenzene	<1,500	2,700	<0.030
142	Phenol	<1,500	<150	<0.030
	Metals			
155	Arsenic	<0.010	<0.010	<0.010
156	Barium	<0.001	0.0078	0.032
159	Chromium	<0.007	0.432	0.0097
160	Copper	<0.006	0.012	<0.006
161	Lead	<0.005	<0.050	<0.500
163	Nickel	<0.011	0.238	<0.011
167	Vanadium	<0.006	<0.006	0.014
168	Zinc	0.021	0.079	0.058
	Inorganics			
169	Total Cyanides	0.0748	6.28	0.565
170	Fluorides	<0.20	<0.20	0.590
171	Sulfides	89.0	<1.0*	<1.0*

a - Onsite Engineering Report for E. I. Dupont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14.

* - Less than detection limit -- caused by interference

Continued

TABLE 4-1 (Continued) TREATMENT DATA FOR SAMPLE SET 1 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING AND ACTIVATED CARBON ADSORPTION

OPERATING PARAMETERS	Design Value	Operating Range
Aniline Liquid/Liquid Extractor :	Solvent - Nitrobenzene	
Feed Rate to the Extractor (lbs/hr)	7,000 - 25,000	14,400 - 14,500
Feed pH to the Extractor	9 - 10**	10.3
Feed Temperature to the Extractor (°C)	40.0**	13.0
Nitrobenzene Liquid/Liquid Extractor :	Solvent - Nitrobenzene	
Feed Rate to the Extractor (lbs/hr)	27,000 - 35,000	21,300 - 46,000^{+}
Feed pH to the Extractor	Max. 2.4	0.2
Feed Temperature to the Extractor (°C)	25.0 - 65.0	39.0
Steam Stripper :		
Top Column Temperature (°C)	Min. 95.0	95***
Pressure Drop Across the Column(inches of water)	Max. 90.0	44.26 - 51.00
Feed Rate to Steam Stripper(lbs/hr)	Min. 20,000, Max. 90,000	59,400 - 59,480
Activated Carbon Adsorption:		
Feed Rate to the System (lbs/hr)	Max. 65,300	61,600 - 68,600^{+}
Feed pH to the System	Min. 7.0	10.6
Feed Temperature to the System (°C)	40.0**	25.0
Total Organic Carbon in treated waste (mg/l)	Max. 250 Instantaneous	79.3
Calculated Residence time (minutes)	Min. 85	81 - 90^{+}

a - Onsite Engineering Report for E. I. duPont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14.

** - Not controlled. Normal operating value is given.

*** - Mid column substituted for top column temperature due to technical difficulties.

+ - Values outside the design range are instantaneous maximum or minimum. Refer to strip charts in Appendix G.

TABLE 4-2 TREATMENT DATA FOR SAMPLE SET 2 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION

	BDAT CONSTITUENTS DETECTED	UNTREATED WASTE K103 (mg/l)	UNTREATED WASTE K104 (mg/l)	TREATED WASTE K103 (mg/l)	TREATED WASTE K104 (mg/l)
	Volatile Organic Compounds				
4	Benzene	73	320	6.3	58
48	Trichloromonofluoromethane	<5	<20	<5	<5
	Semivolatile Organic Compounds				
56	Aniline	33,000	<150	95	<150
101	2,4-Dinitrophenol	<7,500	<750	<300	<750
126	Nitrobenzene	<1,500	2,200	2,800	3,200
142	Phenol	<1,500	<150	<60	<150
	Metals				
155	Arsenic	<0.010	<0.100	NA	NA
156	Barium	<0.001	0.0015	NA	NA
159	Chromium	<0.007	0.097	NA	NA
160	Copper	<0.006	<0.006	NA	NA
161	Lead	<0.005	<0.100	NA	NA
163	Nickel	<0.011	0.055	NA	NA
167	Vanadium	<0.006	<0.006	NA	NA
168	Zinc	0.003	0.011	NA	NA
	Inorganics				
169	Total Cyanides	0.0595	3.30	NA	NA
170	Fluorides	<0.20	<0.20	NA	NA
171	Sulfides	89.0	<1.0*	NA	NA

a - Onsite Engineering Report for E.I. Dupont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3; 6-6, 6-8, and 6-14

NA - Not Analyzed

* - Less than detection limit -- caused by interference

TABLE 4-2 (continued) TREATMENT DATA FOR SAMPLE SET 2 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING

BDAT CONSTITUENTS DETECTED	UNTREATED WASTE K103 (mg/l)	UNTREATED WASTE K104 (mg/l)	TREATED WASTE (mg/l)
Volatile Organic Compounds			
4 Benzene	73	320	0.008
48 Trichloromonofluoromethane	<5	<20	<0.5
Semivolatile Organic Compounds			
56 Aniline	33,000	<150	<3
101 2,4-Dinitrophenol	<7,500	<750	36
126 Nitrobenzene	<1,500	2,200	<3
127 4-Nitrophenol	<7,500	<750	<15
142 Phenol	<1,500	<150	<3
** Benzoic Acid	<7,500	<750	25
Metals			
155 Arsenic	<0.010	<0.100	NA
156 Barium	<0.001	0.0015	NA
159 Chromium	<0.007	0.097	NA
160 Copper	<0.006	<0.006	NA
161 Lead	<0.005	<0.100	NA
163 Nickel	<0.011	0.055	NA
167 Vanadium	<0.006	<0.006	NA
168 Zinc	0.003	0.011	NA
Inorganics			
169 Total Cyanides	0.0595	3.30	3.87
170 Fluorides	<0.20	<0.20	NA
171 Sulfides	89.0	<1.0*	<1.0*

a - Onsite Engineering Report for E.I. Dupont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14

NA - Not Analyzed

* - Less than detection limit -- caused by interference

** - Not on BDAT list of constituents

TABLE 4-2 (continued) TREATMENT DATA FOR SAMPLE SET 2 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING AND ACTIVATED CARBON ADSORPTION

BDAT CONSTITUENTS DETECTED	UNTREATED WASTE K103 (mg/l)	K104 (mg/l)	TREATED WASTE (mg/l)
Volatile Organic Compounds			
4 Benzene	73	320	<0.005
48 Trichloromonofluoromethane	<5	<20	0.010
Semivolatile Organic Compounds			
56 Aniline	33,000	<150	<0.030
101 2,4-Dinitrophenol	<7,500	<750	0.320
126 Nitrobenzene	<1,500	2,200	<0.030
142 Phenol	<1,500	<150	<0.030
Metals			
155 Arsenic	<0.010	<0.100	<0.100
156 Barium	<0.001	0.0015	0.042
159 Chromium	<0.007	0.097	0.024
160 Copper	<0.006	<0.006	<0.006
161 Lead	<0.005	<0.100	<0.050
163 Nickel	<0.011	0.055	<0.011
167 Vanadium	<0.006	<0.006	0.012
168 Zinc	0.003	0.011	0.052
Inorganics			
169 Total Cyanides	0.0595	3.30	0.597
170 Fluorides	<0.20	<0.20	0.420
171 Sulfides	89.0	<1.0*	<1.0*

a - Onsite Engineering Report for E. I. duPont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14.

* - Less than detection limit -- caused by interference

Continued

TABLE 4-2 (Continued) TREATMENT DATA FOR SAMPLE SET 2 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING AND ACTIVATED CARBON ADSORPTION

OPERATING PARAMETERS	Design Value	Operating Range
Aniline Liquid/Liquid Extractor :	Solvent - Nitrobenzene	
Feed Rate to the Extractor (lbs/hr)	7,000 - 25,000	15,900 - 16,000
Feed pH to the Extractor	9 - 10**	10.3
Feed Temperature to the Extractor (°C)	40.0**	22.0
Nitrobenzene Liquid/Liquid Extractor :	Solvent - Nitrobenzene	
Feed Rate to the Extractor (lbs/hr)	27,000 - 35,000	9,800 - 26,000[+]
Feed pH to the Extractor	Max. 2.4	0.2
Feed Temperature to the Extractor (°C)	25.0 - 65.0	43.0
Steam Stripper :		
Top Column Temperature (°C)	Min. 95.0	102.2 - 103.3
Pressure Drop Across the Column(inches of water)	Max. 90.0	42.40 - 58.00
Feed Rate to Steam Stripper(lbs/hr)	Min. 20,000, Max. 90,000	49,000 - 60,100
Activated Carbon Adsorption:		
Feed Rate to the System (lbs/hr)	Max. 65,300	63,000 - 76,000
Feed pH to the System	Min. 7.0	4.6[+]
Feed Temperature to the System (°C)	40.0**	28.0
Total Organic Carbon in treated waste (mg/l)	Max. 250 Instantaneous	73.5
Calculated Residence time (minutes)	Min. 85	73 - 88[+]

[a] - Onsite Engineering Report for E. I. duPont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14.

** - Not controlled. Normal operating value is given.

[+] - Values outside the design range are instantaneous maximum or minimum. Refer to strip charts in Appendix G.

TABLE 4-3 TREATMENT DATA FOR SAMPLE SET 3 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION

BDAT CONSTITUENTS DETECTED		UNTREATED WASTE K103 (mg/l)	UNTREATED WASTE K104 (mg/l)	TREATED WASTE K103 (mg/l)	TREATED WASTE K104 (mg/l)
	Volatile Organic Compounds				
4	Benzene	65	70	3.6	34
48	Trichlorofluoromethane	<2.5	<1	<0.25	<5
	Semivolatile Organic Compounds				
56	Aniline	39,000	<150	<75	<150
101	2,4-Dinitrophenol	<15,000	<750	<374	<750
126	Nitrobenzene	<3,000	2,300	1,900	1,800
142	Phenol	<3,000	<150	<74	<150
	Metals				
155	Arsenic	<0.010	<0.010	NA	NA
156	Barium	<0.001	0.011	NA	NA
159	Chromium	<0.007	<0.007	NA	NA
160	Copper	<0.006	0.0075	NA	NA
161	Lead	<0.005	<0.005	NA	NA
163	Nickel	<0.011	<0.011	NA	NA
167	Vanadium	<0.006	<0.006	NA	NA
168	Zinc	0.0099	0.031	NA	NA
	Inorganics				
169	Total Cyanides	0.0411	5.70	NA	NA
170	Fluorides	<0.20	<0.20	NA	NA
171	Sulfides	74.0	<1.0*	NA	NA

a - Onsite Engineering Report for E.I. Dupont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14

NA - Not Analyzed

* - Less than detection limit -- caused by interference

TABLE 4-3 (continued) TREATMENT DATA FOR SAMPLE SET 3 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING

BDAT CONSTITUENTS DETECTED		UNTREATED WASTE K103 (mg/l)	UNTREATED WASTE K104 (mg/l)	TREATED WASTE (mg/l)
	Volatile Organic Compounds			
4	Benzene	65	70	<0.005
48	Trichloromonofluoromethane	<2.5	<5	<0.005
	Semivolatile Organic Compounds			
56	Aniline	39,000	<150	<1.5
101	2,4-Dinitrophenol	<15,000	<750	47
126	Nitrobenzene	<3,000	2,300	<1.5
127	4-Nitrophenol	<15,000	<750	13
142	Phenol	<3,000	<150	<1.5
**	Benzoic Acid	<15,000	<750	7.9
	Metals			
155	Arsenic	<0.010	<0.010	NA
156	Barium	<0.001	0.011	NA
159	Chromium	<0.007	<0.007	NA
160	Copper	<0.006	0.0075	NA
161	Lead	<0.005	<0.005	NA
163	Nickel	<0.011	<0.011	NA
167	Vanadium	<0.006	<0.006	NA
168	Zinc	0.0099	0.031	NA
	Inorganics			
169	Total Cyanides	0.0411	5.70	2.36
170	Fluorides	<0.20	<0.20	NA
171	Sulfides	74.0	<1.0*	<1.0*

a - Onsite Engineering Report for E.I. Dupont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14

NA - Not Analyzed

* - Less than detection limit -- caused by interference

** - Not on BDAT list of constituents

TABLE 4-3 (continued) TREATMENT DATA FOR SAMPLE SET 3 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING AND ACTIVATED CARBON ADSORPTION

BDAT CONSTITUENTS DETECTED		UNTREATED WASTE K103 (mg/l)	UNTREATED WASTE K104 (mg/l)	TREATED WASTE (mg/l)
	Volatile Organic Compounds			
4	Benzene	65	70	0.018
48	Trichlorofluoromethane	<2.5	<5	<0.005
	Semivolatile Organic Compounds			
56	Aniline	39,000	<150	4.20
101	2,4-Dinitrophenol	<15,000	<750	<0.760
126	Nitrobenzene	<3,000	2,300	<0.150
142	Phenol	<3,000	<150	<0.150
	Metals			
155	Arsenic	<0.010	<0.010	<0.010
156	Barium	<0.001	0.011	0.068
159	Chromium	<0.007	<0.007	0.008
160	Copper	<0.006	0.0075	<0.006
161	Lead	<0.005	<0.005	<0.005
163	Nickel	<0.011	<0.011	<0.011
167	Vanadium	<0.006	<0.006	0.0091
168	Zinc	0.0099	0.031	0.016
	Inorganics			
169	Total Cyanides	0.0411	5.70	0.201
170	Fluorides	<0.20	<0.20	0.220
171	Sulfides	74.0	<1.0*	<1.0*

a - Onsite Engineering Report for E. I. duPont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14.

* - Less than detection limit -- caused by interference

Continued

TABLE 4-3 (Continued) TREATMENT DATA FOR SAMPLE SET 3 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING AND ACTIVATED CARBON ADSORPTION

OPERATING PARAMETERS	Design Value	Operating Range
Aniline Liquid/Liquid Extractor :	Solvent - Nitrobenzene	
Feed Rate to the Extractor (lbs/hr)	7,000 - 25,000	17,600 - 17,800
Feed pH to the Extractor	9 - 10**	10.1
Feed Temperature to the Extractor (°C)	40.0**	24.0
Nitrobenzene Liquid/Liquid Extractor :	Solvent - Nitrobenzene	
Feed Rate to the Extractor (lbs/hr)	27,000 - 35,000	24,100 - 33,000[+]
Feed pH to the Extractor	Max. 2.4	5.7
Feed Temperature to the Extractor (°C)	25.0 - 65.0	42.5
Steam Stripper :		
Top Column Temperature (°C)	Min. 95.0	102.6 - 103.0
Pressure Drop Across the Column(inches of water)	Max. 90.0	46.42 - 50.33
Feed Rate to Steam Stripper(lbs/hr)	Min. 20,000, Max. 90,000	60,200 - 60,400
Activated Carbon Adsorption:		
Feed Rate to the System (lbs/hr)	Max. 65,300	57,700 - 58,140
Feed pH to the System	Min. 7.0	3.1[+]
Feed Temperature to the System (°C)	40.0**	44.0
Total Organic Carbon in treated waste (mg/l)	Max. 250 Instantaneous	10.8
Calculated Residence time (minutes)	Min. 85	96 - 97

a - Onsite Engineering Report for E. I. duPont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14.

** - Not controlled. Normal operating value is given.

+ - Values outside the design range are instantaneous maximum or minimum. Refer to strip charts in Appendix G.

TABLE 4-4 TREATMENT DATA FOR SAMPLE SET 4 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION

BDAT CONSTITUENTS DETECTED	UNTREATED WASTE K103 (mg/l)	UNTREATED WASTE K104 (mg/l)	TREATED WASTE K103 (mg/l)	TREATED WASTE K104 (mg/l)
Volatile Organic Compounds				
4 Benzene	55	11	2.35	26
48 Trichlorofluoromethane	<2.5	<0.5	<0.25	<1
Semivolatile Organic Compounds				
56 Aniline	39,000	<300	<74	<150
101 2,4-Dinitrophenol	<15,000	<1,500	<374	<750
126 Nitrobenzene	<3,000	2,900	2000	2500
142 Phenol	<3,000	<300	<74	<150
Metals				
155 Arsenic	0.021	<0.010	NA	NA
156 Barium	<0.001	0.017	NA	NA
159 Chromium	<0.007	<0.007	NA	NA
160 Copper	<0.006	<0.006	NA	NA
161 Lead	<0.005	<0.005	NA	NA
163 Nickel	<0.011	<0.011	NA	NA
167 Vanadium	<0.006	<0.006	NA	NA
168 Zinc	0.018	0.064	NA	NA
Inorganics				
169 Total Cyanides	<0.0100	3.06	NA	NA
170 Fluorides	<0.20	<0.20	NA	NA
171 Sulfides	62.0	<1.0*	NA	NA

a - Onsite Engineering Report for E.I. Dupont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14

NA - Not Analyzed

* - Less than detection limit -- caused by interference

TABLE 4-4 (continued) TREATMENT DATA FOR SAMPLE SET 4 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING

	UNTREATED WASTE K103	UNTREATED WASTE K104	TREATED WASTE
BDAT CONSTITUENTS DETECTED	(mg/l)	(mg/l)	(mg/l)
Volatile Organic Compounds			
4 Benzene	55	11	<0.005
48 Trichloromonofluoromethane	<2.5	<0.5	<0.005
Semivolatile Organic Compounds			
56 Aniline	39,000	<300	<1.5
101 2,4-Dinitrophenol	<15,000	<1,500	52
126 Nitrobenzene	<3,000	2,900	<1.5
127 4-Nitrophenol	<15,000	<1,500	13
142 Phenol	<3,000	<300	<1.5
Metals			
155 Arsenic	0.021	<0.010	NA
156 Barium	<0.001	0.017	NA
159 Chromium	<0.007	<0.007	NA
160 Copper	<0.006	<0.006	NA
161 Lead	<0.005	<0.005	NA
163 Nickel	<0.011	<0.011	NA
167 Vanadium	<0.006	<0.006	NA
168 Zinc	0.018	0.064	NA
Inorganics			
169 Total Cyanides	<0.0100	3.06	2.08
170 Fluorides	<0.20	<0.20	NA
171 Sulfides	62.0	<1.0*	<1.0*

a - Onsite Engineering Report for E.I. Dupont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14

NA - Not Analyzed

* - Less than detection limit -- caused by interference

** - Not on BDAT list of constituents

TABLE 4-4 (continued) TREATMENT DATA FOR SAMPLE SET 4 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING AND ACTIVATED CARBON ADSORPTION

BDAT CONSTITUENTS DETECTED		UNTREATED WASTE K103 (mg/l)	UNTREATED WASTE K104 (mg/l)	TREATED WASTE (mg/l)
	Volatile Organic Compounds			
4	Benzene	55	11	0.019
48	Trichlorofluoromethane	<2.5	<0.5	<0.005
	Semivolatile Organic Compounds			
56	Aniline	39,000	<300	<0.030
101	2,4-Dinitrophenol	<15,000	<1,500	0.260
126	Nitrobenzene	<3,000	2,900	<0.030
142	Phenol	<3,000	<300	<0.030
	Metals			
155	Arsenic	0.021	<0.010	<0.500
156	Barium	<0.001	0.017	0.076
159	Chromium	<0.007	<0.007	<0.007
160	Copper	<0.006	<0.006	<0.006
161	Lead	<0.005	<0.005	<0.005
163	Nickel	<0.011	<0.011	0.015
167	Vanadium	<0.006	<0.006	<0.006
168	Zinc	0.018	0.064	0.033
	Inorganics			
169	Total Cyanides	<0.0100	3.06	0.156
170	Fluorides	<0.20	<0.20	0.220
171	Sulfides	62.0	<1.0*	<1.0*

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a - Onsite Engineering Report for E. I. duPont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14.

* - Less than detection limit -- caused by interference

Continued

TABLE 4-4 (Continued) TREATMENT DATA FOR SAMPLE SET 4 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING AND ACTIVATED CARBON ADSORPTION

OPERATING PARAMETERS	Design Value	Operating Range
Aniline Liquid/Liquid Extractor :	Solvent - Nitrobenzene	
Feed Rate to the Extractor (lbs/hr)	7,000 - 25,000	14,900 - 15,200
Feed pH to the Extractor	9 - 10**	10.0
Feed Temperature to the Extractor (°C)	40.0**	31.0
Nitrobenzene Liquid/Liquid Extractor :	Solvent - Nitrobenzene	
Feed Rate to the Extractor (lbs/hr)	27,000 - 35,000	12,800 - 35,000+
Feed pH to the Extractor	Max. 2.4	0.8
Feed Temperature to the Extractor (°C)	25.0 - 65.0	50.0
Steam Stripper :		
Top Column Temperature (°C)	Min. 95.0	102.9 - 103.0
Pressure Drop Across the Column(inches of water)	Max. 90.0	44.05 - 46.10
Feed Rate to Steam Stripper(lbs/hr)	Min. 20,000, Max. 90,000	60,300
Activated Carbon Adsorption:		
Feed Rate to the System (lbs/hr)	Max. 65,300	59,900 - 60,000
Feed pH to the System	Min. 7.0	4.0+
Feed Temperature to the System (°C)	40.0**	38.0
Total Organic Carbon in treated waste (mg/l)	Max. 250 Instantaneous	10.0
Calculated Residence time (minutes)	Min. 85	90 - 93

a - Onsite Engineering Report for E. I. duPont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14.

** - Not controlled. Normal operating value is given.

+ - Values outside the design range are instantaneous maximum or minimum. Refer to strip charts in Appendix G.

TABLE 4-5 TREATMENT DATA FOR SAMPLE SET 5 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION

	BDAT CONSTITUENTS DETECTED	UNTREATED WASTE K103 (mg/l)	UNTREATED WASTE K104 (mg/l)	TREATED WASTE K103 (mg/l)	TREATED WASTE K104 (mg/l)
	Volatile Organic Compounds				
4	Benzene	32	4.5	2.75	15
48	Trichlorofluoromethane	<2.5	<0.25	<0.25	<0.5
	Semivolatile Organic Compounds				
56	Aniline	53,000	<300	<150	<300
101	2,4-Dinitrophenol	<15,000	<1,500	<750	<1,500
126	Nitrobenzene	<3,000	3,900	2,000	1,800
142	Phenol	<3,000	<300	<150	<300
	Metals				
155	Arsenic	<0.500	<0.500	NA	NA
156	Barium	<0.001	0.013	NA	NA
159	Chromium	<0.007	0.0071	NA	NA
160	Copper	<0.006	<0.006	NA	NA
161	Lead	0.006	<0.050	NA	NA
163	Nickel	<0.011	0.014	NA	NA
167	Vanadium	<0.006	<0.006	NA	NA
168	Zinc	0.014	0.014	NA	NA
	Inorganics				
169	Total Cyanides	0.0384	4.44	NA	NA
170	Fluorides	<0.20	<0.20	NA	NA
171	Sulfides	80.0	<1.0*	NA	NA

a - Onsite Engineering Report for E.I. Dupont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14

NA - Not Analyzed

* - Less than detection limit -- caused by interference

TABLE 4-5 (continued) TREATMENT DATA FOR SAMPLE SET 5 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING

		UNTREATED WASTE		TREATED WASTE
		K103	K104	
BDAT CONSTITUENTS DETECTED		(mg/l)		(mg/l)
	Volatile Organic Compounds			
4	Benzene	32	4.5	<0.005
48	Trichloromonofluoromethane	<2.5	<0.25	<0.005
	Semivolatile Organic Compounds			
56	Aniline	53,000	<300	<3
101	2,4-Dinitrophenol	<15,000	<1,500	16
126	Nitrobenzene	<3,000	3,900	<3
127	4-Nitrophenol	<15,000	<1,500	<15
142	Phenol	<3,000	<300	<3
	Metals			
155	Arsenic	<0.500	<0.500	NA
156	Barium	<0.001	0.013	NA
159	Chromium	<0.007	0.0071	NA
160	Copper	<0.006	<0.006	NA
161	Lead	0.006	<0.050	NA
163	Nickel	<0.011	0.014	NA
167	Vanadium	<0.006	<0.006	NA
168	Zinc	0.014	0.014	NA
	Inorganics			
169	Total Cyanides	0.0384	4.44	1.70
170	Fluorides	<0.20	<0.20	NA
171	Sulfides	80.0	<1.0*	<1.0*

a - Onsite Engineering Report for E.I. Dupont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14

NA - Not Analyzed

* - Less than detection limit -- caused by interference

** - Not on BDAT list of constituents

TABLE 4-5 (continued) TREATMENT DATA FOR SAMPLE SET 5 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING AND ACTIVATED CARBON ADSORPTION

	BDAT CONSTITUENTS DETECTED	UNTREATED WASTE K103 (mg/l)	UNTREATED WASTE K104 (mg/l)	TREATED WASTE (mg/l)
	Volatile Organic Compounds			
4	Benzene	32	4.5	0.011
48	Trichlorofluoromethane	<2.5	<0.25	<0.005
	Semivolatile Organic Compounds			
56	Aniline	53,000	<300	0.960
101	2,4-Dinitrophenol	<15,000	<1,500	0.230
126	Nitrobenzene	<3,000	3,900	<0.030
142	Phenol	<3,000	<300	0.150
	Metals			
155	Arsenic	<0.500	<0.500	<0.010
156	Barium	<0.001	0.013	0.073
159	Chromium	<0.007	0.0071	0.017
160	Copper	<0.006	<0.006	<0.006
161	Lead	0.006	<0.050	<0.100
163	Nickel	<0.011	0.014	0.030
167	Vanadium	<0.006	<0.006	<0.006
168	Zinc	0.014	0.014	0.012
	Inorganics			
169	Total Cyanides	0.0384	4.44	0.129
170	Fluorides	<0.20	<0.20	0.620
171	Sulfides	80.0	<1.0*	<1.0*

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a - Onsite Engineering Report for E. I. duPont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14.

* - Less than detection limit -- caused by interference

Continued

TABLE 4-5 (Continued) TREATMENT DATA FOR SAMPLE SET 5 - EPA COLLECTED DATA[a]

LIQUID/LIQUID EXTRACTION FOLLOWED BY STEAM STRIPPING AND ACTIVATED CARBON ADSORPTION

OPERATING PARAMETERS	Design Value	Operating Range
Aniline Liquid/Liquid Extractor :	Solvent - Nitrobenzene	
Feed Rate to the Extractor (lbs/hr)	7,000 - 25,000	14,800 - 14,900
Feed pH to the Extractor	9 - 10**	10.2
Feed Temperature to the Extractor (°C)	40.0**	28.0
Nitrobenzene Liquid/Liquid Extractor :	Solvent - Nitrobenzene	
Feed Rate to the Extractor (lbs/hr)	27,000 - 35,000	24,700 - 31,500[+]
Feed pH to the Extractor	Max. 2.4	1.5
Feed Temperature to the Extractor (°C)	25.0 - 65.0	47.5
Steam Stripper :		
Top Column Temperature (°C)	Min. 95.0	102.6 - 102.7
Pressure Drop Across the Column(inches of water)	Max. 90.0	44.80 - 51.80
Feed Rate to Steam Stripper(lbs/hr)	Min. 20,000, Max. 90,000	57,590 - 57,660
Activated Carbon Adsorption:		
Feed Rate to the System (lbs/hr)	Max. 65,300	52,200 - 61,500
Feed pH to the System	Min. 7.0	3.5[+]
Feed Temperature to the System (°C)	40.0**	33.5
Total Organic Carbon in treated waste (mg/l)	Max. 250 Instantaneous	7.0
Calculated Residence time (minutes)	Min. 85	91 - 107

a - Onsite Engineering Report for E. I. duPont de Nemours, Inc., Beaumont, Texas, Tables 4-1 through 4-3, 6-6, 6-8, and 6-14.

** - Not controlled. Normal operating value is given.

+ - Values outside the design range are instantaneous maximum or minimum. Refer to strip charts in Appendix G.

TABLE 4-6 TREATMENT DATA FOR STEAM STRIPPER AND/OR ACTIVATED CARBON ADSORPTION FOR COMBINED K103 AND K104

SOURCE: Organic Chemicals, Plastics and Synthetic Fibers Point Source Category Data Base

Sample Number	UNTREATED WASTE (ug/l)	TREATED WASTE (ug/l)
	NITROBENZENE[b]	
1	*	<14
2	2,460,000	98
3	2,630,000	<14
4	1,690,000	<14
5	3,390,000	<14
6	3,140,000	281
7	780,000	<14
8	4,390,000	2,160
9	2,760,000	<14
10	3,280,000	<14
11	2,340,000	<14
12	448,000	1,960
13	2,500,000	49
14	4,220,000	3,240
15	2,500,000	<14
16	2,760,000	<14
17	5,060,000	26
18	2,810,000	<14
19	2,810,000	96
20	2,300,000	71
21	375,000	240
22	3,460,000	<14
23	2,740,000	<14
24	5,160,000	232
25	5,100,000	234
26	5,460,000	9,800
27	3,610,000	69
28	4,820,000	<14
29	2,760,000	<14
30	2,430,000	<14
31	2,920,000	<14
32	*	77
33	2,200,000	323
34	2,560,000	<14
35	*	<14
36	3,680,000	<14
37	145,000	<14

b - Facility identification number is 500P. Design and operating data was not submitted. Treatment system was steam stripping followed by carbon adsorption.

* - No value given.

TABLE 4-6 TREATMENT DATA FOR STEAM STRIPPER AND/OR ACTIVATED CARBON ADSORPTION FOR COMBINED K103 AND K104 (Continued)

SOURCE: Organic Chemicals, Plastics and Synthetic Fibers Point Source Category Data Base

Sample Number	UNTREATED WASTE (ug/l)	TREATED WASTE (ug/l)
	NITROBENZENE[c]	
38	330,000	374
39	190,000	150
40	267,160	143
41	309,920	330
42	106,995	372
43	144,860	140
44	139,530	4,900
45	87,000	135
46	139,340	331
47	189,054	251
	2,4-DINITROPHENOL[d]	
48	58,155	1,059
49	29,500	<50
50	30,700	1,761
51	37,000	237
52	56,517	<50
53	30,000	<50
54	20,000	<50
55	27,000	<50
56	30,900	<50

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c - Facility identification number is 2680T. Design and operating data is considered CBI. Treatment system was steam stripping followed by carbon adsorption.

d - Facility identification number is 2680T. Treatment system was carbon adsorption.

TABLE 4-6 TREATMENT DATA FOR STEAM STRIPPER AND/OR ACTIVATED CARBON ADSORPTION FOR COMBINED K103 AND K104

SOURCE: Organic Chemicals, Plastics and Synthetic Fibers Point Source Category Data Base

Parameters	Design Range	Operating Range

This information has been claimed as RCRA Confidential Business Information. The information is available in the confidential portion of the Administrative Record for this rulemaking.

Table 4-7

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #1

	Untreated Waste		Treated Waste
Detected BDAT List Organic Constituents	K019 Concentration mg/kg (ppm)	RCRA Blend* Concentration mg/kg (ppm)	Kiln Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<2,000	2,000	<2
7. Carbon tetrachloride	4,000	<8	<2
9. Chlorobenzene	3,000	<8	<2
14. Chloroform	4,600	<8	<2
22. 1,1-Dichloroethane	2,200	<8	<2
23. 1,2-Dichloroethane	93,000	<8	<2
34. Methyl ethyl ketone	<1,000	940	<10
38. Methylene chloride	<1,000	910	<10
42. Tetrachloroethene	7,300	490	<2
43. Toluene	<200	2,300	<2
45. 1,1,1-Trichloroethane	81,000	130	<2
47. Trichloroethene	3,210	360	<2
215-217. Xylene (total)	<200	3,400	<2
222. Acetone	<1,000	1,200	<10
226. Ethyl benzene	<200	2,200	<2
229. Methyl isobutyl ketone	<1,000	1,100	<10
SEMIVOLATILES			
51. Acenaphthalene	<10	150	<2
57. Anthracene	<10	110	<2
65. Benzo(k)fluoranthene	<10	67	<2
68. Bis(2-chloroethyl) ether	280	<20	<2
70. Bis(2-ethylhexyl) phthalate	<10	40	<2
80. Chrysene	SNA	28	<2
87. o-Dichlorobenzene	<10	250	<2
88. p-Dichlorobenzene	81	32	<2
98. Di-n-butyl phthalate	<10	31	<2
108. Fluoranthene	<10	120	<2
109. Fluorene	20	53	<2
110. Hexachlorobenzene	69	<100	<10

SNA A standard is not available; the compound was searched using an NBS Library database of 42,000 compounds. The compound was not detected.

* Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-7 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #1 (Continued)

	Untreated Waste		Treated Waste	
Detected BDAT List Organic Constituents	K019 Concentration mg/kg (ppm)	RCRA Blend* Concentration mg/kg (ppm)	Kiln Ash Concentration mg/kg (ppm)	Kiln Ash TCLP mg/L (ppm)
SEMIVOLATILES (Continued)				
111. Hexachlorobutadiene	<50	210	<10	
113. Hexachloroethane	120	<100	<10	
121. Naphthalene	470	<20	<2	
126. Nitrobenzene	<25	3,400	<5	
136. Pentachlorobenzene	61	<100	<10	
141. Phenanthrene	21	240	<2	
142. Phenol	<10	78	<2	
145. Pyrene	<10	200	<2	
148. 1,2,4,5-Tetrachlorobenzene	76	<50	<5	
150. 1,2,4-Trichlorobenzene	100	<50	<5	
Detected BDAT List Metal and Inorganic Constituents				
METALS				
154. Antimony	<6.0	24	8.0	<0.060
155. Arsenic	1.2	94	3.6	<0.002
156. Barium	0.97	1.3	26	0.033
158. Cadmium	0.63	<0.3	0.66	<0.003
159. Chromium	4.0	40	44	0.200
160. Copper	2.1	165	2,370	2.690
161. Lead	3.4	27	120	0.380
163. Nickel	3.0	8.8	66	0.680
165. Silver	<0.9	<0.9	3.3	<0.009
167. Vanadium	<2.0	2.2	4.1	<0.020
168. Zinc	5.8	4,170	12	0.052
INORGANICS				
169. Total Cyanide	<0.5	0.9	<0.47	
170. Fluoride	<5.0	31	38	
171. Sulfide	790	830	68	

*Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-7 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #1 (Continued)

DESIGN AND OPERATING PARAMETERS

Parameter	Design	Operating Value
Kiln Temperature (°F)+	*	1825-1900
Kiln Solids Residence Time (mi	*	120
Waste Feed Rate (MMBTU/hr)+	*	K019: 13.1 RCRA Blend, Waste Burner #1: 3.9-5.5 RCRA Blend, Waste Burner #2: 4.4-9.7
Kiln Rotational Speed (RPM)	*	0.19-0.21

+Strip charts for this parameter are included in Appendix C.

*This information has been claimed as RCRA Confidential Business Information. The information is available in the confidential portion of the Administrative Record for this rulemaking.

Table 4-8

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #2

Detected BDAT List Organic Constituents	Untreated Waste		Treated Waste
	K019 Concentration mg/kg (ppm)	RCRA Blend* Concentration mg/kg (ppm)	Kiln Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<2,000	2,000	<2
7. Carbon tetrachloride	3,800	<8	<2
9. Chlorobenzene	<2,000	<8	<2
14. Chloroform	5,800	<8	<2
22. 1,1-Dichloroethane	<2,000	<8	<2
23. 1,2-Dichloroethane	96,000	<8	<2
34. Methyl ethyl ketone	<10,000	940	<10
38. Methylene chloride	<10,000	910	<10
42. Tetrachloroethene	6,700	490	<2
43. Toluene	<2,000	2,300	<2
45. 1,1,1-Trichloroethane	33,000	130	<2
47. Trichloroethene	2,400	360	<2
215-217. Xylene (total)	<2,000	3,400	<2
222. Acetone	<10,000	1,200	<10
226. Ethyl benzene	<2,000	2,200	<2
229. Methyl isobutyl ketone	<10,000	1,100	<10
SEMIVOLATILES			
51. Acenaphthalene	<10	150	<2
57. Anthracene	<10	110	<2
65. Benzo(k)fluoranthene	<10	67	<2
68. Bis(2-chloroethyl) ether	280	<20	<2
70. Bis(2-ethylhexyl) phthalate	<10	40	<2
80. Chrysene	SNA	28	<2
87. o-Dichlorobenzene	<10	250	<2
88. p-Dichlorobenzene	74	32	<2
98. Di-n-butyl phthalate	<10	31	<2
108. Fluoranthene	<10	120	<2
109. Fluorene	16	53	<2
110. Hexachlorobenzene	60	<100	<10

SNA A standard is not available; the compound was searched using an NBS Library database of 42,000 compounds. The compound was not detected.

* Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-8 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #2 (Continued)

	Untreated Waste		Treated Waste	
Detected BDAT List Organic Constituents	K019 Concentration mg/kg (ppm)	RCRA Blend* Concentration mg/kg (ppm)	Kiln Ash Concentration mg/kg (ppm)	Kiln Ash TCLP mg/L (ppm)
SEMIVOLATILES (Continued)				
111. Hexachlorobutadiene	<50	210	<10	
113. Hexachloroethane	85	<100	<10	
121. Naphthalene	314	<20	<2	
126. Nitrobenzene	<25	3,400	<5	
136. Pentachlorobenzene	51	<100	<10	
141. Phenanthrene	15	240	<2	
142. Phenol	<10	78	<2	
145. Pyrene	<10	200	<2	
148. 1,2,4,5-Tetrachlorobenzene	62	<50	<5	
150. 1,2,4-Trichlorobenzene	65	<50	<5	
Detected BDAT List Metal and Inorganic Constituents				
METALS				
154. Antimony	<6.0	24	6.8	<0.060
155. Arsenic	<0.2	94	2.8	<0.002
156. Barium	<0.9	1.3	23	0.036
158. Cadmium	0.46	<0.3	0.96	0.004
159. Chromium	3.4	40	60	0.130
160. Copper	1.7	165	3,430	2.380
161. Lead	2.3	27	42	0.260
163. Nickel	3.6	8.8	89	0.560
165. Silver	<0.9	<0.9	3.4	<0.009
167. Vanadium	<2.0	2.2	4.8	<0.020
168. Zinc	6.9	4,170	13	0.071
INORGANICS				
169. Total Cyanide	<0.5	0.9	<0.47	
170. Fluoride	<5.0	31	5.1	
171. Sulfide	NA	830	<50	

NA Not Analyzed.

*Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-8 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #2 (Continued)

DESIGN AND OPERATING PARAMETERS

Parameter	Design	Operating Value
Kiln Temperature (^{o}F)+	*	1800-1880
Kiln Solids Residence Time (min)	*	120
Waste Feed Rate (MMBTU/hr)+	*	K019: 12.2 RCRA Blend, Waste Burner #1: 5.2-5.5 RCRA Blend, Waste Burner #2: 4.4-9.7
Kiln Rotational Speed (RPM)	*	0.19-0.21

+Strip charts for this parameter are included in Appendix C.

*This information has been claimed as RCRA Confidential Business Information. The information is available in the confidential portion of the Administrative Record for this rulemaking.

Table 4-9

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #3

	Untreated Waste		Treated Waste
Detected BDAT List Organic Constituents	K019 Concentration mg/kg (ppm)	RCRA Blend* Concentration mg/kg (ppm)	Kiln Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<2,000	2,000	<2
7. Carbon tetrachloride	3,500	<8	<2
9. Chlorobenzene	<2,000	<8	<2
14. Chloroform	5,000	<8	<2
22. 1,1-Dichloroethane	<2,000	<8	<2
23. 1,2-Dichloroethane	87,000	<8	<2
34. Methyl ethyl ketone	<10,000	940	<10
38. Methylene chloride	<10,000	910	<10
42. Tetrachloroethene	6,000	490	<2
43. Toluene	<2,000	2,300	<2
45. 1,1,1-Trichloroethane	34,000	130	<2
47. Trichloroethene	2,200	360	<2
215-217. Xylene (total)	<2,000	3,400	<2
222. Acetone	<10,000	1,200	<10
226. Ethyl benzene	<2,000	2,200	<2
229. Methyl isobutyl ketone	<10,000	1,100	<10
SEMIVOLATILES			
51. Acenaphthalene	<10	150	<2
57. Anthracene	<10	110	<2
65. Benzo(k)fluoranthene	<10	67	<2
68. Bis(2-chloroethyl) ether	290	<20	<2
70. Bis(2-ethylhexyl) phthalate	<10	40	<2
80. Chrysene	SNA	28	<2
87. o-Dichlorobenzene	<10	250	<2
88. p-Dichlorobenzene	80	32	<2
98. Di-n-butyl phthalate	<10	31	<2
108. Fluoranthene	<10	120	<2
109. Fluorene	19	53	<2
110. Hexachlorobenzene	73	<100	<10

SNA A standard is not available; the compound was searched using an NBS Library database of 42,000 compounds. The compound was not detected.

* Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-9 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #3 (Continued)

	Untreated Waste		Treated Waste	
Detected BDAT List Organic Constituents	K019 Concentration mg/kg (ppm)	RCRA Blend* Concentration mg/kg (ppm)	Kiln Ash Concentration mg/kg (ppm)	Kiln Ash TCLP mg/L (ppm)
SEMIVOLATILES (Continued)				
111. Hexachlorobutadiene	<50	210	<10	
113. Hexachloroethane	95	<100	<10	
121. Naphthalene	350	<20	<2	
126. Nitrobenzene	<25	3,400	<5	
136. Pentachlorobenzene	59	<100	<10	
141. Phenanthrene	11	240	<2	
142. Phenol	<10	78	<2	
145. Pyrene	<10	200	<2	
148. 1,2,4,5-Tetrachlorobenzene	67	<50	5	
150. 1,2,4-Trichlorobenzene	70	<50	<5	
Detected BDAT List Metal and Inorganic Constituents				
METALS				
154. Antimony	<6.0	24	9.2	<0.060
155. Arsenic	<0.2	94	5.7	<0.002
156. Barium	<0.9	1.3	54	0.057
158. Cadmium	0.53	<0.3	3.6	0.005
159. Chromium	3.5	40	202	0.260
160. Copper	1.7	165	2,290	7.030
161. Lead	3.4	27	118	0.620
163. Nickel	2.3	8.8	169	0.960
165. Silver	<0.9	<0.9	1.9	<0.009
167. Vanadium	<2.0	2.2	6.0	<0.020
168. Zinc	4.4	4,170	16	0.170
INORGANICS				
169. Total Cyanide	<0.5	0.9	<0.47	
170. Fluoride.	<5.0	31	6.1	
171. Sulfide	NA	830	64	

NA = Not Analyzed.

* Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-9 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #3 (Continued)

DESIGN AND OPERATING PARAMETERS

Parameter	Design	Operating Value
Kiln Temperature (°F)+	*	1850-1900
Kiln Solids Residence Time (min)	*	120
Waste Feed Rate (MMBTU/hr)+	*	K019: 12.4 RCRA Blend, Waste Burner #1: 5.2-5.8 RCRA Blend, Waste Burner #2: 4.4-8.4
Kiln Rotational Speed (RPM)	*	0.19-0.21

+Strip charts for this parameter are included in Appendix C.

*This information has been claimed as RCRA Confidential Business Information. The information is available in the confidential portion of the Administrative Record for this rulemaking.

Table 4-10

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #4

	Untreated Waste		Treated Waste
Detected BDAT List Organic Constituents	K019 Concentration mg/kg (ppm)	RCRA Blend* Concentration mg/kg (ppm)	Kiln Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<2,000	2,000	<2
7. Carbon tetrachloride	3,900	<8	<2
9. Chlorobenzene	<2,000	<8	<2
14. Chloroform	5,300	<8	<2
22. 1,1-Dichloroethane	<2,000	<8	<2
23. 1,2-Dichloroethane	122,000	<8	<2
34. Methyl ethyl ketone	<10,000	940	<10
38. Methylene chloride	<10,000	910	<10
42. Tetrachloroethene	7,200	490	<2
43. Toluene	<2,000	2,300	<2
45. 1,1,1-Trichloroethane	44,000	130	<2
47. Trichloroethene	2,300	360	<2
215-217. Xylene (total)	<2,000	3,400	<2
222. Acetone	<10,000	1,200	<10
226. Ethyl benzene	<2,000	2,200	<2
229. Methyl isobutyl ketone	<10,000	1,100	<10
SEMIVOLATILES			
51. Acenaphthalene	<10	150	<2
57. Anthracene	<10	110	<2
65. Benzo(k)fluoranthene	<10	67	<2
68. Bis(2-chloroethyl) ether	310	<20	<2
70. Bis(2-ethylhexyl) phthalate	<10	40	12
80. Chrysene	SNA	28	<2
87. o-Dichlorobenzene	<10	250	<2
88. p-Dichlorobenzene	84	32	<2
98. Di-n-butyl phthalate	<10	31	230
108. Fluoranthene	<10	120	<2
109. Fluorene	21	53	<2
110. Hexachlorobenzene	61	<100	<10

SNA A standard is not available; the compound was searched using an NBS Library database of 42,000 compounds. The compound was not detected.

*Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-10 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #4 (Continued)

	Untreated Waste		Treated Waste	
Detected BDAT List Organic Constituents	K019 Concentration mg/kg (ppm)	RCRA Blend* Concentration mg/kg (ppm)	Kiln Ash Concentration mg/kg (ppm)	Kiln Ash TCLP mg/L (ppm)
SEMIVOLATILES (Continued)				
111. Hexachlorobutadiene	<50	210	<10	
113. Hexachloroethane	94	<100	<10	
121. Naphthalene	360	<20	<2	
126. Nitrobenzene	<25	3,400	<5	
136. Pentachlorobenzene	64	<100	<10	
141. Phenanthrene	19	240	<2	
142. Phenol	<10	78	<2	
145. Pyrene	<10	200	<2	
148. 1,2,4,5-Tetrachlorobenzene	82	<50	<5	
150. 1,2,4-Trichlorobenzene	74	<50	<5	
Detected BDAT List Metal and Inorganic Constituents				
METALS				
154. Antimony	<6.0	24	<6.0	<0.060
155. Arsenic	<0.2	94	5.7	<0.002
156. Barium	<0.9	1.3	8.4	0.036
158. Cadmium	<0.3	<0.3	<0.3	0.005
159. Chromium	1.8	40	28	0.110
160. Copper	<1.0	165	1,270	1.940
161. Lead	2.4	27	25	0.320
163. Nickel	2.2	8.8	69	0.870
165. Silver	<0.9	<0.9	2.6	<0.009
167. Vanadium	<2.0	2.2	<2.0	<0.020
168. Zinc	9.4	4,170	11	0.056
INORGANICS				
169. Total Cyanide	<0.5	0.9	<0.47	
170. Fluoride	<5.0	31	3.2	
171. Sulfide	NA	830	<50	

NA = Not Analyzed.

* Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-10 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #4 (Continued)

DESIGN AND OPERATING PARAMETERS

Parameter	Design	Operating Value
Kiln Temperature (°F)+	*	1775-1900
Kiln Solids Residence Time (min)	*	120
Waste Feed Rate (MMBTU/hr)+	*	K019: 12.7 RCRA Blend, Waste Burner #1: 5.2-5.8 RCRA Blend, Waste Burner #2: 4.4-7.3
Kiln Rotational Speed (RPM)	*	0.19-0.21

+Strip charts for this parameter are included in Appendix C.

*This information has been claimed as RCRA Confidential Business Information. The information is available in the confidential portion of the Administrative Record for this rulemaking.

Table 4-11

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #5

	Untreated Waste		Treated Waste
Detected BDAT List Organic Constituents	K019 Concentration mg/kg (ppm)	RCRA Blend* Concentration mg/kg (ppm)	Kiln Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<2,000	2,000	<2
7. Carbon tetrachloride	4,000	<8	<2
9. Chlorobenzene	<2,000	<8	<2
14. Chloroform	6,000	<8	<2
22. 1,1-Dichloroethane	<2,000	<8	<2
23. 1,2-Dichloroethane	130,000	<8	<2
34. Methyl ethyl ketone	<10,000	940	<10
38. Methylene chloride	<10,000	910	<10
42. Tetrachloroethene	7,800	490	<2
43. Toluene	<2,000	2,300	<2
45. 1,1,1-Trichloroethane	45,000	130	<2
47. Trichloroethene	2,500	360	<2
215-217. Xylene (total)	<2,000	3,400	<2
222. Acetone	<10,000	1,200	<10
226. Ethyl benzene	<2,000	2,200	<2
229. Methyl isobutyl ketone	<10,000	1,100	<10
SEMIVOLATILES			
51. Acenaphthalene	<10	150	<2
57. Anthracene	<10	110	<2
65. Benzo(k)fluoranthene	<10	67	<2
68. Bis(2-chloroethyl) ether	340	<20	<2
70. Bis(2-ethylhexyl) phthalate	<10	40	<2
80. Chrysene	SNA	28	<2
87. o-Dichlorobenzene	<10	250	<2
88. p-Dichlorobenzene	90	32	<2
98. Di-n-butyl phthalate	<10	31	<2
108. Fluoranthene	<10	120	<2
109. Fluorene	19	53	<2
110. Hexachlorobenzene	87	<100	<10

SNA A standard is not available; the compound was searched using an NBS Library database of 42,000 compounds. The compound was not detected.

* Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-11 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #5 (Continued)

	Untreated Waste		Treated Waste	
Detected BDAT List Organic Constituents	K019 Concentration mg/kg (ppm)	RCRA Blend* Concentration mg/kg (ppm)	Kiln Ash Concentration mg/kg (ppm)	Kiln Ash TCLP mg/L (ppm)
SEMIVOLATILES (Continued)				
111. Hexachlorobutadiene	<50	210	<10	
113. Hexachloroethane	113	<100	<10	
121. Naphthalene	371	<20	<2	
126. Nitrobenzene	<25	3,400	<5	
136. Pentachlorobenzene	63	<100	<10	
141. Phenanthrene	19	240	<2	
142. Phenol	<10	78	<2	
145. Pyrene	<10	200	<2	
148. 1,2,4,5-Tetrachlorobenzene	73	<50	<5	
150. 1,2,4-Trichlorobenzene	72	<50	<5	
Detected BDAT List Metal and Inorganic Constituents				
METALS				
154. Antimony	<6.0	24	9.1	<0.060
155. Arsenic	<0.2	94	3.9	<0.002
156. Barium	<0.9	1.3	21	0.054
158. Cadmium	0.36	<0.3	1.2	0.006
159. Chromium	3.2	40	125	0.210
160. Copper	2.1	165	2,780	2.140
161. Lead	2.5	27	86	0.290
163. Nickel	4.8	8.8	166	1.270
165. Silver	<0.9	<0.9	3.3	<0.009
167. Vanadium	<2.0	2.2	5.7	<0.020
168. Zinc	4.7	4,170	22	0.086
INORGANICS				
169. Total Cyanide	<0.5	0.9	<0.47	
170. Fluoride	<5.0	31	23	
171. Sulfide	NA	830	64	

NA = Not Analyzed.

*Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-11 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019 PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #5 (Continued)

DESIGN AND OPERATING PARAMETERS

Parameter	Design	Operating Value
Kiln Temperature (°F)+	*	1775-1800
Kiln Solids Residence Time (min)	*	120
Waste Feed Rate (MMBTU/hr)+	*	K019: 11.7 RCRA Blend, Waste Burner #1: 5.2-6.0 RCRA Blend, Waste Burner #2: 5.2-9.7
Kiln Rotational Speed (RPM)	*	0.19-0.21

+Strip charts for this parameter are included in Appendix C.

*This information has been claimed as RCRA Confidential Business Information. The information is available in the confidential portion of the Administrative Record for this rulemaking.

Table 4-12

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #6

Detected BDAT List Organic Constituents	Untreated Waste K019 Concentration mg/kg (ppm)	Untreated Waste RCRA Blend* Concentration mg/kg (ppm)	Treated Waste Kiln Ash Concentration mg/kg (ppm)
VOLATILES			
4. Benzene	<2,000	2,000	<2
7. Carbon tetrachloride	4,100	<8	<2
9. Chlorobenzene	<2,000	<8	<2
14. Chloroform	5,600	<8	<2
22. 1,1-Dichloroethane	<2,000	<8	<2
23. 1,2-Dichloroethane	98,000	<8	<2
34. Methyl ethyl ketone	<10,000	940	<10
38. Methylene chloride	<10,000	910	<10
42. Tetrachloroethene	6,900	490	<2
43. Toluene	<2,000	2,300	<2
45. 1,1,1-Trichloroethane	44,000	130	<2
47. Trichloroethene	2,500	360	<2
215-217. Xylene (total)	<2,000	3,400	<2
222. Acetone	<10,000	1,200	<10
226. Ethyl benzene	<2,000	2,200	<2
229. Methyl isobutyl ketone	<10,000	1,100	<10
SEMIVOLATILES			
51. Acenapthalene	<10	150	<2
57. Anthracene	<10	110	<2
65. Benzo(k)fluoranthene	<10	67	<2
68. Bis(2-chloroethyl) ether	330	<20	<2
70. Bis(2-ethylhexyl) phthalate	<10	40	<2
80. Chrysene	SNA	28	<2
87. o-Dichlorobenzene	<10	250	<2
88. p-Dichlorobenzene	90	32	<2
98. Di-n-butyl phthalate	<10	31	<2
108. Fluoranthene	<10	120	<2
109. Fluorene	22	53	<2
110. Hexachlorobenzene	66	<100	<10

SNA A standard is not available; the compound was searched using an NBS Library database of 42,000 compounds. The compound was not detected.

* Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-12 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET #6 (Continued)

	Untreated Waste		Treated Waste	
Detected BDAT List Organic Constituents	K019 Concentration mg/kg (ppm)	RCRA Blend* Concentration mg/kg (ppm)	Kiln Ash Concentration mg/kg (ppm)	Kiln Ash TCLP mg/L (ppm)
SEMIVOLATILES (Continued)				
111. Hexachlorobutadiene	<50	210	<10	
113. Hexachloroethane	88	<100	<10	
121. Naphthalene	390	<20	<2	
126. Nitrobenzene	<25	3,400	<5	
136. Pentachlorobenzene	65	<100	<10	
141. Phenanthrene	17	240	<2	
142. Phenol	<10	78	<2	
145. Pyrene	<10	200	<2	
148. 1,2,4,5-Tetrachlorobenzene	86	<50	<5	
150. 1,2,4-Trichloroenzene	79	<50	<5	
Detected BDAT List Metal and Inorganic Constituents				
METALS				
154. Antimony	<6.0	24	9.6	< 0.06
155. Arsenic	<0.2	94	2.3	<0.002
156. Barium	<0.9	1.3	11	0.027
158. Cadmium	0.62	<0.3	2.2	0.006
159. Chromium	5.3	40	141	0.092
160. Copper	3.6	165	2,520	2.400
161. Lead	3.5	27	34	0.270
163. Nickel	6.0	8.8	288	0.690
165. Silver	<0.9	<0.9	3.1	<0.009
167. Vanadium	<2.0	2.2	8.7	<0.020
168. Zinc	8.4	4,170	13	0.061
INORGANICS				
169. Total Cyanide	<0.5	0.9	<0.47	
170. Fluoride	<5.0	31	4.7	
171. Sulfide	NA	830	92	

NA = Not Analyzed.

*Only one sample of RCRA Blend waste was taken. The results are repeated in each sample set.

Table 4-12 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K019
PLANT A - ROTARY KILN INCINERATOR

SAMPLE SET 6 (Continued)

DESIGN AND OPERATING PARAMETERS

Parameter	Design	Operating Value
Kiln Temperature (°F)+	*	1775-1850
Kiln Solids Residence Time (min)	*	120
Waste Feed Rate (MMBTU/hr)+	*	K019: 11.5 RCRA Blend, Waste Burner #1: 5.2-5.8 RCRA Blend, Waste Burner #2: 5.2-9.7
Kiln Rotational Speed (RPM)	*	0.19-0.21

+Strip charts for this parameter are included in Appendix C.

*This information has been claimed as RCRA Confidential Business Information. The information is available in the confidential portion of the Administrative Record for this rulemaking.

Table 4-13

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A-FLUIDIZED BED INCINERATION

Sample Set #1

Detected BDAT List Organic Constituents	Untreated Waste K048* Concentration mg/kg (ppm)	Untreated Waste K051 Concentration mg/kg (ppm)	Treated Waste Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES			
21. Dichlorodifluoromethane	310	<14	<2
226. Ethyl benzene	46	48	<2
43. Toluene	120	50	3
215-217. Xylene (total)	120	80	<2
SEMIVOLATILES			
52. Acenaphthene	<20	33	<0.2
59. Benz(a)anthracene	<20	29	<0.2
70. Bis(2-ethylhexyl)phthalate	<20	28	<1.0
80. Chrysene	22	46	<0.2
98. Di-n-butyl phthalate	67	150	<1.0
109. Fluorene	31	33	<0.2
121. Naphthalene	100	160	<0.2
141. Phenanthrene	85	120	<0.2
145. Pyrene	35	66	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-13 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #1 (Continued)

	Untreated Waste		Treated Waste Fluidized Bed Incinerator Ash	
Detected BDAT List Metal and Inorganic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Concentration mg/kg (ppm)	TCLP mg/L (ppm)
154. Antimony	<6	9	16	0.06
155. Arsenic	6.1	8.2	14	0.016
156. Barium	63	120	130	0.18
157. Beryllium	<0.1	<0.1	<0.1	<0.001
158. Cadmium	0.6	1.6	2.4	<0.003
221. Chromium (hexavalent)	<0.05	22@	21	NA
159. Chromium (total)	890	730	1400	2.2
160. Copper	52	150	190	0.02
161. Lead	400	940	940	<0.05
162. Mercury	<0.02	0.19	<0.02	0.0003
163. Nickel	13	36	60	<0.02
164. Selenium	10	1.6	<0.3	0.033
165. Silver	<0.9	<0.9	<4	<0.009
167. Vanadium	430	260	690	2.8
168. Zinc	420	820	1000	0.079
INORGANICS				
169. Total cyanide	0.7	0.8	<0.1	
171. Sulfide	130	2900	<50	

NA = Not Analyzed

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

@Colorimetric interference may have occurred in analysis of this sample.

Table 4-13 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A-FLUIDIZED BED INCINERATION

Sample Set #1 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1213-1240
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1240-1253
API Separator Sludge Feed Rate (gpm)	0-24	22.3
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	43
Constriction Plate Pressure Differential (In. H_2O)+	15-20	10.7-18.7
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	90.4-102.4
O_2 (% Volume)	NA	8.2-16.2
CO (ppm-Volume)	35-800	50-135
CO_2 (% Volume)	NA	2.2-9.0

+Strip charts for this parameter are included in Appendix E.

NA Not applicable

Table 4-14

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #2

		Untreated Waste		Treated Waste
Detected BDAT List Organic Constituents		K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES				
21.	Dichlorodifluoromethane	260	<14	<2
226.	Ethyl benzene	120	46	<2
43.	Toluene	22	44	<2
215-217.	Xylene (total)	110	71	<2
SEMIVOLATILES				
52.	Acenaphthene	<20	<20	<0.2
59.	Benz(a)anthracene	<20	25	<0.2
70.	Bis(2-ethylhexyl)phthalate	<20	<20	<1.0
80.	Chrysene	<20	47	<0.2
98.	Di-n-butyl phthalate	74	73	<1.0
109.	Fluorene	31	37	<0.2
121.	Naphthalene	110	160	<0.2
141.	Phenanthrene	79	120	<0.2
145.	Pyrene	31	67	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-14 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #2 (Continued)

	Untreated Waste		Treated Waste Fluidized Bed Incinerator Ash	
Detected BDAT List Metal and Inorganic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Concentration mg/kg (ppm)	TCLP mg/L (ppm)
METALS				
154. Antimony	7	<6	13	0.06
155. Arsenic	5.4	6.7	19	0.008
156. Barium	67	73	160	0.24
157. Beryllium	<0.1	<0.1	<0.1	<0.001
158. Cadmium	0.7	1.3	3	<0.003
221. Chromium (hexavalent)	<0.05	<0.05	24	NA
159. Chromium (total)	940	860	1500	2.6
160. Copper	55	150	240	0.02
161. Lead	390	670	1100	<0.05
162. Mercury	0.11	0.23	<0.02	<0.0002
163. Nickel	14	30	74	<0.02
164. Selenium	9.9	1.1	<0.3	<0.02
165. Silver	<0.9	<0.9	<4.0	<0.009
167. Vanadium	450	290	730	2.5
168. Zinc	450	580	1100	0.086
INORGANICS				
169. Total cyanide	<0.1	0.5	0.4	
171. Sulfide	200	3600	<50	

NA = Not analyzed

* K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-14 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #2 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1227-1323
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1253-1293
API Separator Sludge Feed Rate (gpm)	0-24	22.3
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	53
Constriction Plate Pressure Differential (In. H_2O)+	15-20	8.7-18.0
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	91.2-104.0
O_2 (% Volume)	NA	9.2-16.0
CO (ppm-Volume)	35-800	80-355
CO_2 (% Volume)	NA	2.3-8.1

+Strip charts for this parameter are included in Appendix E.

NA = Not applicable.

Table 4-15

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A - FLUIDIZED BED INCINERATION

Sample Set #3

	Untreated Waste		Treated Waste
Detected BDAT List Organic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES			
21. Dichlorodifluoromethane	<14	<14	<2
226. Ethyl benzene	33	52	<2
43. Toluene	59	42	<2
215-217. Xylene (total)	100	73	<2
SEMIVOLATILES			
52. Acenaphthene	<20	<20	<0.2
59. Benz(a)anthracene	<20	22	<0.2
70. Bis(2-ethylhexyl) phthalate	<20	30	<1.0
80. Chrysene	21	45	<0.2
98. Di-n-butyl phthalate	160	200	<1.0
109. Fluorene	32	35	<0.2
121. Naphthalene	110	150	<0.2
141. Phenanthrene	84	110	<0.2
145. Pyrene	33	62	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-15 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A - FLUIDIZED BED INCINERATION

Sample Set #3 (Continued)

Detected BDAT List Metal and Inorganic Constituents	Untreated Waste: K048* Concentration mg/kg (ppm)	Untreated Waste: K051 Concentration mg/kg (ppm)	Treated Waste, Fluidized Bed Incinerator Ash: Concentration mg/kg (ppm)	Treated Waste, Fluidized Bed Incinerator Ash: TCLP mg/L (ppm)
METALS				
154. Antimony	<6	18	13	0.09
155. Arsenic	5.7	9.7	13	0.022
156. Barium	68	100	140	0.17
157. Beryllium	<0.1	<0.1	0.5	<0.001
158. Cadmium	0.4	1.5	2	<0.003
221. Chromium (hexavalent)	<0.05	<0.05	23	NA
159. Chromium (total)	960	900	1300	2.1
160. Copper	56	160	200	0.02
161. Lead	410	790	1100	<0.05
162. Mercury	0.12	0.28	<0.02	<0.0002
163. Nickel	16	35	51	<0.02
164. Selenium	7.5	1.2	<0.3	0.085
165. Silver	<0.9	<0.9	<4	<0.009
167. Vanadium	460	300	690	3.1
168. Zinc	450	670	1000	0.087
INORGANICS				
169. Total cyanide	<0.1	<0.1	<0.1	
171. Sulfide	2300	3200	<50	

NA = Not Analyzed

* K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-15 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #3 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1227-1287
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1253-1287
API Separator Sludge Feed Rate (gpm)	0-24	22.3-22.4
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	50
Constriction Plate Pressure Differential (In. H_2O)+	15-20	9.3-18.7
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	91.2-104.0
O_2 (% Volume)	NA	9.5-16.8
CO (ppm-Volume)	35-800	45-140
CO_2 (% Volume)	NA	2.2-8.6

+Strip charts for this parameter are included in Appendix E.

NA = Not analyzed.

Table 4-16

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A-FLUIDIZED BED INCINERATION

Sample Set #4

Detected BDAT List Organic Constituents	Untreated Waste K048* Concentration mg/kg (ppm)	Untreated Waste K051 Concentration mg/kg (ppm)	Treated Waste Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES			
21. Dichlorodifluoromethane	<14	<14	<2
226. Ehtyl benzene	<14	50	<2
43. Toluene	28	33	<2
215-217. Xylene (total)	79	72	5.8
SEMIVOLATILES			
52. Acenaphthene	<20	<20	<0.2
59. Benz(a)anthracene	<20	23	<0.2
70. Bis(2-ethylhexyl)phthalate	59	26	<1.0
80. Chrysene	<20	48	<0.2
98. Di-n-butyl phthalate	190	170	<1.0
109. Fluorene	31	35	<0.2
121. Naphthalene	93	150	<0.2
141. Phenanthrene	77	120	<0.2
145. Pyrene	31	74	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-16 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #4 (Continued)

	Untreated Waste		Treated Waste Fluidized Bed Incinerator Ash	
Detected BDAT List Metal and Inorganic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Concentration mg/kg (ppm)	TCLP mg/L (ppm)
METALS				
154. Antimony	<6	15	17	0.06
155. Arsenic	4.9	7.5	14	0.015
156. Barium	61	92	180	0.25
157. Beryllium	<0.1	<0.1	0.7	<0.001
158. Cadmium	<0.3	1.4	2	<0.003
221. Chromium (hexavalent)	<0.05	<0.05	24	NA
159. Chromium (total)	840	960	1600	2.3
160. Copper	49	140	240	0.02
161. Lead	340	690	1200	<0.05
162. Mercury	0.13	0.07	<0.02	0.0003
163. Nickel	14	37	80	<0.02
164. Selenium	8.7	0.9	<0.3	0.11
165. Silver	<0.9	<0.9	<4	<0.009
167. Vanadium	390	320	790	2.7
168. Zinc	400	650	1100	0.086
INORGANICS				
169. Total cyanide	1	1.4	0.5	
171. Sulfide	2500	4800	<50	

NA = Not Analyzed

* K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-16 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #4 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1200-1260
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1253-1273
API Separator Sludge Feed Rate (gpm)	0-24	22.3-22.4
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	61
Constriction Plate Pressure Differential (In. H_2O)+	15-20	8.7-18.3
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	91.2-105.6
O_2 (% Volume)	NA	10.5-17.0
CO (ppm-Volume)	35-800	40-340
CO_2 (% Volume)	NA	2.8-7.9

+Strip charts for this parameter are included in Appendix E.

NA = Not applicable.

Table 4-17

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051 PLANT A-FLUIDIZED BED INCINERATION

Sample Set #5

Detected BDAT List Organic Constituents	Untreated Waste K048* Concentration mg/kg (ppm)	Untreated Waste K051 Concentration mg/kg (ppm)	Treated Waste Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES			
21. Dichlorodifluoromethane	<14	<14	<2
226. Ethyl benzene	41	49	<2
43. Toluene	41	34	<2
215-217. Xylene (total)	110	71	<2
SEMIVOLATILES			
52. Acenaphthene	<20	<20	<0.2
59. Benz(a)anthracene	<20	24	<0.2
70. Bis(2-ethylhexyl)phthalate	21	28	<1.0
80. Chrysene	22	47	<0.2
98. Di-n-butyl phthalate	74	230	<1.0
109. Fluorene	32	37	<0.2
121. Naphthalene	94	160	<0.2
141. Phenanthrene	83	120	<0.2
145. Pyrene	34	74	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-17 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #5 (Continued)

Detected BDAT List Metal and Inorganic Constituents	Untreated Waste: K048* Concentration mg/kg (ppm)	Untreated Waste: K051 Concentration mg/kg (ppm)	Treated Waste, Fluidized Bed Incinerator Ash: Concentration mg/kg (ppm)	Treated Waste, Fluidized Bed Incinerator Ash: TCLP mg/L (ppm)
METALS				
154. Antimony	<6	9	16	0.06
155. Arsenic	5.5	8.3	13	0.022
156. Barium	59	100	180	0.20
157. Beryllium	<0.1	<0.1	0.6	<0.001
158. Cadmium	<0.3	1.7	2	<0.003
221. Chromium (hexavalent)	<0.05	<0.05	40	NA
159. Chromium (total)	810	1100	1600	3.4
160. Copper	47	170	240	0.02
161. Lead	330	700	1300	<0.05
162. Mercury	0.16	0.31	<0.02	0.0003
163. Nickel	14	37	70	<0.02
164. Selenium	11	0.5	<0.3	0.12
165. Silver	<0.9	1.4	<4	<0.009
167. Vanadium	370	350	830	2.9
168. Zinc	380	680	1100	0.079
INORGANICS				
169. Total cyanide	<0.1	<0.1	<0.1	
171. Sulfide	2800	4000	<50	

NA = Not Analyzed

* K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-17(Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #5 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1220-1253
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1253-1267
API Separator Sludge Feed Rate (gpm)	0-24	22.3
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	53
Constriction Plate Pressure Differential (In. H_2O)+	15-20	8.7-18.7
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	92.8-105.6
O_2 (% Volume)	NA	10.8-17.3
CO (ppm-Volume)	35-800	30-910
CO_2 (% Volume)	NA	2.8-7.5

+Strip charts for this parameter are included in Appendix E.

NA = Not applicable.

Table 4-18

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A-FLUIDIZED BED INCINERATION

Sample Set #6

Detected BDAT List Organic Constituents	Untreated Waste: K048* Concentration mg/kg (ppm)	Untreated Waste: K051 Concentration mg/kg (ppm)	Treated Waste: Fluidized Bed Incinerator Ash Concentration mg/kg (ppm)
VOLATILES			
21. Dichlorodifluoromethane	<14	<14	<2
226. Ethyl benzene	49	52	<2
43. Toluene	34	71	<2
215-217. Xylene (total)	<14	83	<2
SEMIVOLATILES			
52. Acenaphthene	<20	<20	<0.2
59. Benz(a)anthracene	<20	25	<0.2
70. Bis(2-ethylhexyl)phthalate	<20	<20	<1.0
80. Chrysene	<20	51	<0.2
98. Di-n-butyl phthalate	130	43	<1.0
109. Fluorene	31	36	<0.2
121. Naphthalene	98	170	<0.2
141. Phenanthrene	86	120	<0.2
145. Pyrene	31	67	<0.2

*K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-18 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #6 (Continued)

	Untreated Waste		Treated Waste Fluidized Bed Incinerator Ash	
Detected BDAT List Metal and Inorganic Constituents	K048* Concentration mg/kg (ppm)	K051 Concentration mg/kg (ppm)	Concentration mg/kg (ppm)	TCLP mg/L (ppm)
METALS				
154. Antimony	<6	<6	15	0.07
155. Arsenic	5.4	5.4	16	0.025
156. Barium	61	72	180	0.21
157. Beryllium	<0.1	<0.1	<0.1	<0.001
158. Cadmium	0.4	1.2	3.1	<0.003
221. Chromium (hexavalent)	<0.05	<0.05	30	NA
159. Chromium (total)	830	840	1700	2.1
160. Copper	48	130	250	0.02
161. Lead	350	640	1100	<0.05
162. Mercury	0.14	0.11	<0.02	<0.0002
163. Nickel	13	26	73	0.03
164. Selenium	11	0.9	<0.3	0.12
165. Silver	<0.9	<0.9	<4	<0.009
167. Vanadium	380	280	910	3.6
168. Zinc	390	570	1200	0.11
INORGANICS				
169. Total cyanide	0.9	0.6	0.5	
171. Sulfide	360	3400	<50	

NA = Not Analyzed

* K048 is a dewatered mixture of DAF float (K048) and waste biosludge.

Table 4-18 (Continued)

TREATMENT PERFORMANCE DATA COLLECTED BY EPA FOR K048 AND K051
PLANT A - FLUIDIZED BED INCINERATION

Sample Set #6 (Continued)

Design and Operating Parameters	Nominal Operating Range	Operating Range During Sampling Episode
Bed Temperature (F)+	1200-1300 (1400 max.)	1220-1240
Freeboard Temperature (F)+	1250-1350 (1450 max.)	1253-1267
API Separator Sludge Feed Rate (gpm)	0-24	22.3
Undewatered DAF Float Mixture Feed Rate (gpm)	30-90	61
Constriction Plate Pressure Differential (In. H_2O)+	15-20	10.0-18.0
Fluidized Bed Pressure Differential (In. H_2O)+	60-100	92.8-105.6
O_2 (% Volume)	NA	10.8-16.0
CO (ppm-Volume)	35-800	50-770
CO_2 (% Volume)	NA	5.7-7.7

+Strip charts for this parameter are included in Appendix E.

NA = Not applicable.

5. IDENTIFICATION OF BEST DEMONSTRATED AVAILABLE TREATMENT TECHNOLOGY (BDAT) FOR K103 AND K104

5.1 Introduction

In this section, EPA explains its determination of which technologies represent BDAT for K103 and K104 waste groups. As discussed in detail in Section 1, this determination essentially involves determining which of the "demonstrated" technologies will provide the "best" treatment and, at the same time, is determined to be "available" (i.e., the technology can be purchased or licensed and provides substantial treatment).

In general, performance data are screened according to the following three conditions:

- Proper design and operation of the treatment system;
- The existence of quality assurance/quality control measures in the data analysis; and
- The use of proper analytical tests in assessing treatment performance.

Sets of performance data that do not meet these three conditions are not considered in the selection of BDAT. In addition, if performance data indicate that the treatment system was not well-designed and well-operated at the time of testing, these data would also not be used.

The remaining performance data are then corrected to account for incomplete recovery of certain constituents during the analyses. Finally, in cases where the Agency has adequate performance data for treatment of the waste by more than one technology, an analysis of variance (ANOVA) test is used to select the best treatment technology. Before the ANOVA calculations could be done, the data had to be screened and accuracy-corrected. This is explained below.

The Agency specifically collected performance data for the treatment of waste codes K103 and K104 from one treatment technology system: liquid/liquid extraction followed by steam stripping and activated carbon adsorption. These data are shown in Section 4. Review of the operating performance of the system, compared to the design and operating standards (also shown in Section 4), indicates that the system represents a well-designed and well-operated system. In searching for additional performance data for these waste streams, the Agency found data for steam stripping followed by carbon adsorption in an effluent guidelines database (USEPA 1987a). These data do not include all of the constituents found in the specific data collected under the BDAT program. All of the design and operating standards for the effluent treatment system necessary to fully evaluate the utility of these data are not available. Since the input waste and treated waste concentration values are in the same order of magnitude as the BDAT data, it would appear that substantial treatment occurred and it was a well-designed and well-operated system. However, this assumption is not fully supported by the data available. The validity and utility of these data will be further discussed in Section 7.

5.2 Data Screening

Wastewaters

In the selection of BDAT for treatment of K103 and K104 wastewaters, the only performance data available were those collected during the Agency's sampling visit. Five data sets were collected by the Agency for treatment of the wastewaters by liquid/liquid extraction followed by steam stripping and carbon adsorption. These data were evaluated to determine whether any of the data represented poor design or poor operation of the system. One of the data sets (Sample Set 3) was deleted because of poor operation of the carbon adsorption unit during the time data were being collected. This was indicated by a higher than normal system temperature and a relatively high aniline concentration in the treated waste. The four remaining data sets were used for the development of treatment standards for K103 and K104 wastewaters. These data sets are Sample Sets 1, 2, 4 and 5.

Nonwastewaters

In the selection of BDAT for treatment of K103 and K104 nonwastewaters, the only performance data available were those transferred from waste codes K019 and K048-K052. Six sample sets were available from both K019 and K048-K052. None of the data sets were deleted because of poor design or poor operation of the treatment system.

5.3 Data Accuracy

After data were eliminated from consideration for analysis of BDAT based on the screening tests, the Agency adjusted the remaining data using analytical recovery values to take into account analytical interferences and incomplete recoveries associated with the chemical makeup of the sample. The Agency developed the recovery data (also referred to as accuracy data) by first analyzing a waste for a given constituent and then adding a known amount of the same constituent (i.e., spike) to the waste material. The total amount recovered after spiking, minus the initial concentration in the sample, divided by the amount added, is the recovery value. At least two recovery values were calculated for spiked constituents, and the analytical data were adjusted for accuracy using the lowest recovery value for each constituent.

This was accomplished by calculating an accuracy factor from the percent recoveries for each selected constituent. The reciprocal of the lower of the two recovery values, divided by 100, yields the accuracy factor. The corrected concentration for each sample set is obtained by multiplying the accuracy factor by the raw data value. The actual recovery values and accuracy factors for the selected constituents are presented in Appendix E.

5.4 Analysis of Variance

In cases where the Agency has adequate performance data on treatment of the same or similar wastes using more than one technology, an analysis of variance (ANOVA) test is performed to determine if one of the technologies provides significantly better treatment than the others. In cases where a particular treatment technology is shown to provide better treatment, the treatment standards will be based on this best technology. The procedure followed for the analysis of variance (ANOVA) test is described in Appendix A.

5.5 Wastewaters

As explained in Section 3, EPA has determined that the "demonstrated" technologies for K103 and K104 are as follows:

- Liquid/liquid extraction;
- Liquid/liquid extraction followed by steam stripping; and
- Liquid/liquid extraction followed by steam stripping; and activated carbon adsorption.

Of these three treatment trains, EPA has determined that liquid/liquid extraction followed by steam stripping and activated carbon adsorption provides the "best" level of treatment.

EPA compared the performance achieved by reduction in organic constituents. Consistent with EPA's methodology, discussed in Section 1, EPA made this comparison using a statistical test known as the analysis of variance (ANOVA) test.

To determine BDAT for waste codes K103 and K104, three combinations of demonstrated technologies, for which adequate performance data were available, were considered for the treatment of these wastes:

- Liquid/liquid extraction;
- Liquid/liquid extraction followed by steam stripping; and
- Liquid/liquid extraction followed by steam stripping and activated carbon adsorption.

The corrected data for sample sets 1, 2, 4, and 5 were used to perform analysis of variance (ANOVA) tests to compare these three technology combinations. The three combinations of treatment technologies were compared based on the concentration of primary waste constituents (benzene, aniline, nitrobenzene, phenol, 2,4-dinitrophenol, and total cyanides) in the treated waste. The rationale for selecting these constituents for the ANOVA comparison is presented in Section 7.

The statistical results of the ANOVA test for liquid/liquid extraction followed by steam stripping versus liquid/liquid extraction indicate the following:

1. Liquid/liquid extraction followed by steam stripping provides significantly better treatment for benzene and nitrobenzene in waste codes K103 and K104 than does liquid/liquid extraction alone.

2. Liquid/liquid extraction followed by steam stripping provides equivalent treatment for total cyanides in waste codes K103 and K104 compared to liquid/liquid extraction alone.

3. Insufficient data exist to compare the treatment for phenol, aniline, and 2,4-dinitrophenol achieved by liquid/liquid extraction alone with that achieved by liquid/liquid extraction followed by steam stripping.

The statistical results of the ANOVA test of liquid/liquid extraction followed by steam stripping and activated carbon adsorption versus liquid/liquid extraction followed by steam stripping indicate the following:

1. Liquid/liquid extraction followed by steam stripping and activated carbon adsorption provides significantly better treatment for aniline, 2,4-dinitrophenol, phenol, and total cyanides in waste codes K103 and K104 than does liquid/liquid extraction followed by steam stripping.

2. Liquid/liquid extraction followed by steam stripping and activated carbon adsorption provides equivalent treatment for benzene in waste codes K103 and K104 compared to liquid/liquid extraction followed by steam stripping.

3. Insufficient data exist to compare the treatment for nitrobenzene achieved by liquid/liquid extraction followed by steam stripping with that achieved by liquid/liquid extraction followed by steam stripping and activated carbon adsorption.

The three-step treatment technology system consisting of liquid/liquid extraction followed by steam stripping and activated carbon adsorption provides significantly better or equivalent treatment overall for the primary constituents present in waste codes K103 and K104 when compared with either liquid/liquid extraction alone or liquid/liquid extraction followed by steam stripping. Therefore, the Agency has chosen this three-step treatment system to be BDAT for waste codes K103 and K104.

Substantial treatment for K103 and K104 wastewaters is based on the following observations for reduction in total concentrations (see Table 5-1 at the end of this section). Benzene is reduced from 81 mg/l to 0.007 mg/l, aniline from 53,000 mg/l to 0.033 mg/l, and total cyanides from 6.28 mg/l to 0.179 mg/l. In addition, the Agency believes that 2,4-dinitrophenol was substantially reduced to 0.288 mg/l, nitrobenzene to 0.026 mg/l, and phenol to 0.143 mg/l. These three constituents were not detected in the untreated waste because the detection limits for these three constituents were relatively high.

The Agency believes the reduction in the range and magnitude of these hazardous constituents to be substantial. For K103 and K104 wastewaters, liquid/liquid extraction followed by steam stripping and activated carbon adsorption has been determined to be demonstrated and best, has provided substantial treatment, and is commercially available, and, therefore, represents BDAT.

5.6 Nonwastewaters

Substantial treatment for K103 and K104 nonwastewater is based on the following observation for reduction in total concentrations (see Table 5-2). Chlorobenzene is reduced from 3,000 ppm, chloroform from 6,000 ppm, 1,2-dichloroethane from 130,000 ppm, tetrachloroethene from 7,800 ppm, 1,1,1-trichloro- ethene from 81,000 ppm, bis(2-chloroethyl)ether from 340 ppm, naphthalene from 470 ppm and phenanthrene from 21 ppm, all to <2 ppm. Hexachloroethane is reduced from 120 ppm to <10 ppm and 1,2,4-trichlorobenzene from 100 to <5 ppm.

The Agency believes the reduction in the range and magnitude of these hazardous constituents to be substantial. For K103 and K104 nonwastewaters, incineration has been determined to be demonstrated and best, has provided substantial treatment, and is commercially available, and, therefore, represents BDAT.

TABLE 5-1 K103 and K104 Wastewater Data Showing Substantial Treatment*

DATA TYPE	Source	Benzene	Aniline	2,4-Dinitrophenol	Nitrobenzene	Phenol	Total Cyanides
Untreated K103	(1)	32 - 81	33,000 - 53,000	<7,500 - <15,000	1,500 - <3,000	<300 - <3,000	0.038 - 0.075
Untreated K104	(1)	4.5 - 320	<150 - <300	<750 - <1,500	2,200 - 3,900	<150 - <300	3.06 - 6.28
Accuracy-Corrected Treated	(2)	0.007 - 0.055	0.033 - 1.056	0.288 - 0.475	0.026	0.143 - 0.714	0.179 - 0.830

* - Range of data points given in mg/l. For individual sample points see Tables 4-1 thru 4-5.

1. Onsite Engineering Report for E.I. du Pont de Nemours, Inc., Beaumont, Texas, Tables 6-6, 6-8 and 6-14.

2. Calculations shown in Appendix D of this Background Document.

TABLE 5-2 K019 and K048/K052 Nonwastewater Data Showing Substantial Treatment*

BDAT List Constituent	K019 mg/kg (ppm) Untreated	K019 Treated	K048/K052 Untreated	K048/K052 Treated
Volatiles:				
Chlorobenzene	<2,000 - 3,000	<2	N/A	N/A
Chloroform	4,600 - 6,000	<2	N/A	N/A
1,2-Dichloroethane	87,000 - 130,000	<2	N/A	N/A
Tetrachloroethene**	6,000 - 7,800	<2	N/A	N/A
1,1,1-Trichloroethene**	33,000 - 81,000	<2	N/A	N/A
Semivolatiles:				
Bis(2-chloroethyl)ether	280 - 340	<2	N/A	N/A
Hexachloroethane**	85 - 120	<10	N/A	N/A
Naphthalene	314 - 470	<2	N/A	N/A
Phenanthrene	11 - 21	<2	N/A	N/A
1,2,4-Trichlorobenzene**	65 - 100	<5	N/A	N/A
Inorganics:				
Cyanides (Total)	<0.5	<0.47	<0.1 - 0.9	<0.1 - 0.5

* - For individual sample points see Background Document for K019, Tables 4-1 thru 4-5.

** - The Agency believes the detection limits for these constituents were abnormally high due to matrix interferences. These constituents were therefore eliminated from consideration when transferring performance data to K103 and K104 nonwastewaters.

N/A - Not Applicable

6. SELECTION OF REGULATED CONSTITUENTS

As discussed in Section 1, the Agency has developed a list of hazardous constituents (Table 1-1) from which the constituents to be regulated are selected. EPA may revise this list as additional data and information become available. The list is divided into the following categories: volatile organics, semivolatile organics, metals, inorganics other than metals, organochlorine pesticides, phenoxyacetic acid herbicides, organophosphorous insecticides, PCBs, and dioxins and furans.

This section describes the process used to select the constituents to be regulated for K103 and K104. The process involves developing a list (or classes) of potential regulated constituents and then eliminating those constituents that would not be treated by the chosen BDAT or that would be controlled by regulation of the remaining constituents.

As discussed in Sections 2 and 4, the Agency has characterization data as well as performance data from treatment of K103 and K104. All these data, as well as information on the waste-generating process, have been used to determine which BDAT- list constituents may be present in the waste and thus which are potential candidates for regulation in K103 and K104 wastewater.

Table 6-1 shows which constituents were analyzed, which constituents were detected, and which constituents the Agency believes to be present even though not detected in the untreated waste. For constituents that were detected, the concentration range is shown.

Under the column "Believed to be present," those constituents marked with Y have been detected in the treated residual(s), and thus EPA believes that they are present in the untreated waste. Constituents may not have been detected in the untreated waste for one of several reasons: (1) none of the untreated waste samples were analyzed for these constituents; (2) masking or interference by other constituents prevented detection; or (3) the specific waste is defined as being generated by a process and the process can involve a number of different constituents, only some of which would be present in any given sample.

As shown in Table 6-1, 16 constituents have been detected and one has been identified as believed to be present. Of these constituents, EPA has selected aniline, benzene, 2,4-dinitro- phenol, nitrobenzene, phenol, and cyanide (total) for regulation. Of the ten not being regulated, one is believed to be treatable. EPA is not regulating this constituent because it is controlled by the treatment of the other regulated constituents.

TABLE 6-1 BDAT List Constituents in Untreated K103 and K104 Waste

	Parameter	Untreated K103 (mg/l)	Believed to be Present	Untreated K104 (mg/l)	Believed to be Present
	Volatiles				
222	Acetone	ND		ND	
1	Acetonitrile	ND		ND	
2	Acrolein	ND		ND	
3	Acrylonitrile	ND		ND	
4	Benzene	32 - 81		4.5 - 320	
5	Bromodichloromethane	ND		ND	
6	Bromomethane	ND		ND	
223	n-Butyl alcohol	ND		ND	
7	Carbon Tetrachloride	ND		ND	
8	Carbon disulfide	ND		ND	
9	Chlorobenzene	ND		ND	
10	2-Chloro-1,3-butadiene	ND		ND	
11	Chlorodibromomethane	ND		ND	
12	Chloroethane	ND		ND	
13	2-Chloroethyl vinyl ether	ND		ND	
14	Chloroform	ND		ND	
15	Chloromethane	ND		ND	
16	3-Chloropropene	ND		ND	
17	1,2-Dibromo-3-chloropropane	ND		ND	
18	1,2-Dibromoethane	ND		ND	
19	Dibromomethane	ND		ND	
20	trans-1,4-Dichloro-2-butene	ND		ND	
21	Dichlorodifluoromethane	ND		ND	
22	1,1-Dichloroethene	ND		ND	
23	1,2-Dichloroethane	ND		ND	
24	1,1-Dichloroethylene	ND		ND	
25	trans-1,2-Dichloroethene	ND		ND	
26	1,2-Dichloropropane	ND		ND	
27	trans-1,3-Dichloropropene	ND		ND	
28	cis-1,3-Dichloropropene	ND		ND	
29	1,4-Dioxane	ND		ND	
224	2-Ethoxyethanol	ND		ND	
225	Ethyl acetate	ND		ND	
226	Ethyl benzene	ND		ND	
30	Ethyl cyanide	ND		ND	
227	Ethyl ether	ND		ND	
31	Ethyl methacrylate	ND		ND	
214	Ethylene oxide	ND		ND	
32	Iodomethane	ND		ND	

ND - Not detected

TABLE 6-1 BDAT List Constituents in Untreated K103 and K104 Waste (Continued)

	Parameter	Untreated K103 (mg/l)	Believed to be Present	Untreated K104 (mg/l)	Believed to be Present
	Volatiles (continued)				
33	Isobutyl alcohol	ND		ND	
228	Methanol	ND		ND	
34	Methyl ethyl ketone	ND		ND	
229	Methyl isobutyl ketone	ND		ND	
35	Methyl methacrylate	ND		ND	
37	Methylacrylonitrile	ND		ND	
38	Methylene chloride	ND		ND	
230	2-Nitropropane	ND		ND	
39	Pyridine	ND		ND	
40	1,1,1,2-Tetrachloroethane	ND		ND	
41	1,1,2,2-Tetrachloroethane	ND		ND	
42	Tetrachloroethene	ND		ND	
43	Toluene	ND		ND	
44	Tribromomethane	ND		ND	
45	1,1,1-Trichloroethane	ND		ND	
46	1,1,2-Trichloroethane	ND		ND	
47	Trichloroethene	ND		ND	
48	Trichloromonofluromethane	ND	Y	ND	Y
49	1,2,3-Trichloropropane	ND		ND	
231	1,1,2-Trichloro-1,2,2-trifluoroethane	ND		ND	
50	Vinyl chloride	ND		ND	
215	1,2-Xylene	ND		ND	
216	1,3-Xylene	ND		ND	
217	1,4-Xylene	ND		ND	
	Semivolatiles				
51	Acenaphthalene	ND		ND	
52	Acenaphthene	ND		ND	
53	Acetophenone	ND		ND	
54	2-Acetylaminofluorene	ND		ND	
55	4-Aminobiphenyl	ND		ND	
56	Aniline	33000 - 53000		ND	
57	Anthracene	ND		ND	
58	Aramite	ND		ND	
59	Benz(a)anthracene	ND		ND	
218	Benzal chloride	ND		ND	
60	Benzenethiol	ND		ND	
61	Benzidine	ND		ND	
62	Benzo(a)pyrene	ND		ND	

Y - Detected in the treated waste.

ND - Not detected

** - Indicates that only one sample contained this constituent at detectable levels.

TABLE 6-1 BDAT List Constituents in Untreated K103 and K104 Waste (Continued)

	Parameter	Untreated K103 (mg/l)	Believed to be Present	Untreated K104 (mg/l)	Believed to be Present
	Semivolatiles (continued)				
63	Benzo(b)fluoranthene	ND		ND	
64	Benzo(ghi)perylene	ND		ND	
65	Benzo(k)fluoranthene	ND		ND	
66	p-Benzoquinone	ND		ND	
67	Bis(2-chloroethoxy)ethane	ND		ND	
68	Bis(2-chloroethyl)ether	ND		ND	
69	Bis(2-chloroisopropy)ether	ND		ND	
70	Bis(2-ethylhexy)phthalate	ND		ND	
71	4-Bromophenyl phenyl ether	ND		ND	
72	Butyl benzyl phthlate	ND		ND	
73	2-sec-Butyl-4,6-dinitrophenol	ND		ND	
74	p-Chloroaniline	ND		ND	
75	Chlorobenzilate	ND		ND	
76	p-Chloro-m-cresol	ND		ND	
77	2-Chloronaphthalene	ND		ND	
78	2-Chlorophenol	ND		ND	
79	3-Chloropropionitrile	ND		ND	
80	Chrysene	ND		ND	
81	ortho-Cresol	ND		ND	
82	para-Cresol	ND		ND	
232	Cyclohexanone	ND		ND	
83	Dibenz(a,h)anthracene	ND		ND	
84	Dibenzo(a,e)pyrene	ND		ND	
85	Dibenzo(a,i)pyrene	ND		ND	
86	m-Dichlorobenzene	ND		ND	
87	o-Dichlorobenzene	ND		ND	
88	p-Dichlorobenzene	ND		ND	
89	3,3'-Dichlorobenzidine	ND		ND	
90	2,4-Dichlorophenol	ND		ND	
91	2,6-Dichlorophenol	ND		ND	
92	Diethyl phthalate	ND		ND	
93	3,3'-Dimethyoxlbenzidine	ND		ND	
94	p-Dimethylaminoazobenzene	ND		ND	
95	3,3'-Dimethylbenzidine	ND		ND	
96	2,4-Dimethylphenol	ND		ND	
97	Dimethyl phthalate	ND		ND	
98	Di-n-butyl phthalate	ND		ND	
99	1,4-Dinitrobenzene	ND		ND	
100	4,6-Dinitro-o-cresol	ND		ND	
101	2,4-Dinitrophenol	ND		ND	

ND - Not detected

TABLE 6-1 BDAT List Constituents in Untreated K103 and K104 Waste (Continued)

	Parameter	Untreated K103 (mg/l)	Believed to be Present	Untreated K104 (mg/l)	Believed to be Present
	Semivolatiles (cont.)				
102	2,4-Dinitrotoluene	ND		ND	
103	2,6-Dinitrotoluene	ND		ND	
104	Di-n-octyl phthalate	ND		ND	
105	Di-n-propylnitrosamine	ND		ND	
106	Diphenylamine	ND		ND	
219	Diphenylnitrosamine	ND		ND	
107	1,2-Diphenylhydrazine	ND		ND	
108	Fluoranthene	ND		ND	
109	Fluorene	ND		ND	
110	Hexachlorobenzene	ND		ND	
111	Hexachlorobutadiene	ND		ND	
112	Hexachlorocyclopentadiene	ND		ND	
113	Hexachloroethane	ND		ND	
114	Hexachlorophene	ND		ND	
115	Hexachloropropene	ND		ND	
116	Indeno(1,2,3-cd)pyrene	ND		ND	
117	Isosafrole	ND		ND	
118	Methapyrilene	ND		ND	
119	3-Methycholanthrene	ND		ND	
120	4,4'-Methylenebis(2-chloroaniline)	ND		ND	
36	Methyl methanesulfonate	ND		ND	
121	Napthalene	ND		ND	
122	1,4-Naphthoquinone	ND		ND	
123	1-Napthylamine	ND		ND	
124	2-Napthylamine	ND		ND	
125	p-Nitroaniline	ND		ND	
126	Nitrobenzene	ND		2200 - 3900	
127	4-Nitrophenol	ND		ND	
128	N-Nitrosodi-n-butylamine	ND		ND	
129	N-Nitrosodiethylamine	ND		ND	
130	N-Nitrosodimethylamine	ND		ND	
131	N-Nitrosomethylethylamine	ND		ND	
132	N-Nitrosomorpholine	ND		ND	
133	N-Nitrosopiperidine	ND		ND	
134	n-Nitrosopyrrolidine	ND		ND	
135	5-Nitro-o-toluidine	ND		ND	
136	Pentachlorobenzene	ND		ND	
137	Pentachloroethane	ND		ND	
138	Pentachloronitrobenzene	ND		ND	

ND - Not detected

TABLE 6-1 BDAT List Constituents in Untreated K103 and K104 Waste (Continued)

Parameter	Untreated K103 (mg/l)	Believed to be Present	Untreated K104 (mg/l)	Believed to be Present
Semivolatiles (cont.)				
139 Pentachlorophenol	ND		ND	
140 Phenacetin	ND		ND	
141 Phenanthrene	ND		ND	
142 Phenol	ND		ND	
220 Phthalic anhydride	ND		ND	
143 2-Picoline	ND		ND	
144 Pronamide	ND		ND	
145 Pyrene	ND		ND	
146 Resorcinol	ND		ND	
147 Safrole	ND		ND	
148 1,2,4,5-Tetrachlorobenzene	ND		ND	
149 2,3,4,6-Tetrachlorophenol	ND		ND	
150 1,2,4-Trichlorobenzene	ND		ND	
151 2,4,5-Trichlorophenol	ND		ND	
152 2,4,6-Trichlorophenol	ND		ND	
153 Tris(2,3-dibromopropyl)phosphate	ND		ND	
Metals				
154 Antimony	ND		ND	
155 Arsenic	0.021**		ND	
156 Barium	ND		0.0015 - 0.017	
157 Beryllium	ND		ND	
158 Cadmium	ND		ND	
159 Chromium	ND		0.007 - 0.432	
221 Chromium (hexavalent)	ND		ND	
160 Copper	ND		0.012**	
161 Lead	0.006**		ND	
162 Mercury	ND		ND	
163 Nickel	ND		0.014 - 0.238	
164 Selenium	ND		ND	
165 Silver	ND		ND	
166 Thallium	ND		ND	
167 Vanadium	ND		ND	
168 Zinc	0.003 - 0.021		0.011 - 0.079	
Inorganics				
169 Cyanide	0.038 - 0.075		3.06 - 6.28	
170 Fluoride	ND		ND	
171 Sulfide	62.0 - 89.0		ND	

** - Indicates that only one sample contained this constituent at detectable levels.

TABLE 6-1 BDAT List Constituents in Untreated K103 and K104 Waste (Continued)

Parameter	Untreated K103 (mg/l)	Believed to be Present	Untreated K104 (mg/l)	Believed to be Present
Organochlorine Pesticides				
172 Aldrin	NA		NA	
173 alpha-BHC	NA		NA	
174 beta-BHC	NA		NA	
175 delta-BHC	NA		NA	
176 gamma-BHC	NA		NA	
177 Chlordane	NA		NA	
178 DDD	NA		NA	
179 DDE	NA		NA	
180 DDT	NA		NA	
181 Dieldrin	NA		NA	
182 Endosulfan I	NA		NA	
183 Endosulfan II	NA		NA	
184 Endrin	NA		NA	
185 Endrin aldehyde	NA		NA	
186 Heptachlor	NA		NA	
187 Heptachlor epoxide	NA		NA	
188 Isodrin	NA		NA	
189 Kepone	NA		NA	
190 Mehoxychlor	NA		NA	
191 Toxaphene	NA		NA	
Phenoxyacetic Acid Herbicides				
192 2,4-Dichlorophenoxyacetic acid	NA		NA	
193 Silvex	NA		NA	
194 2,4,5-T	NA		NA	
Organophosphorous Insecticides				
195 Disulfoton	NA		NA	
196 Famphur	NA		NA	
197 Methyl parathion	NA		NA	
198 Paration	NA		NA	
199 Phorate	NA		NA	
PCBs				
200 Aroclor 1016	ND		ND	
201 Aroclor 1221	ND		ND	
202 Aroclor 1232	ND		ND	

ND - Not detected

NA - Not analyzed

TABLE 6-1 BDAT List Constituents in Untreated K103 and K104 Waste (Continued)

	Parameter	Untreated K103 (mg/l)	Believed to be Present	Untreated K104 (mg/l)	Believed to be Present
	PCBs (continued)				
203	Aroclor 1242	ND		ND	
204	Aroclor 1248	ND		ND	
205	Aroclor 1254	ND		ND	
206	Aroclor 1260	ND		ND	
	Dioxins and Furans				
207	Hexachlorodibenzo-p-dioxins	ND		ND	
208	Hexachlorodibenzofuran	ND		ND	
209	Pentachlorodibenzo-p-dioxins	ND		ND	
210	Pentachlorodibenzofuran	ND		ND	
211	Tetrachlorodibenzo-p-dioxins	ND		ND	
212	Tetrachlorodibenzofuran	ND		ND	
213	2,3,7,8-Tetrachlorodibenzo-p-dioxin	ND		ND	

ND - Not detected

7. CALCULATION OF BDAT TREATMENT STANDARDS

In this section, the treatment standards for waste codes K103 and K104 are presented. These standards were calculated based on the performance of the treatment system that was determined by the Agency to represent the best demonstrated available technology for K103 and K104. In Section 5, BDAT for K103 and K104 wastewaters was determined to be liquid/liquid extraction followed by steam stripping and activated carbon adsorption; BDAT for K103 and K104 nonwastewaters was determined to be incineration. The previous section identified the constituents to be regulated for the wastewater and nonwastewater forms of K103 and K104 wastes.

As discussed in Section 1, the Agency calculated the BDAT treatment standards for waste codes K103 and K104 by following a four-step procedure: (1) editing the data; (2) correcting the remaining data for analytical interference; (3) calculating adjustment factors (variability factors) to account for process variability; and (4) calculating the actual treatment standards using variability factors and average treatment values. The four steps in this procedure are discussed in detail in Sections 7.1 through 7.4.

7.1 Editing the Data

Five sets of treatment data for waste codes K103 and K104 were collected by the Agency at one facility, which operated a treatment system consisting of liquid/liquid extraction followed by steam stripping and activated carbon adsorption. The Agency evaluated the five data sets to determine whether the treatment system was well operated at the time of the sampling visit. The Agency eliminated one data set, Sample Set 3, because the treatment system was not well operated when the samples were collected (as discussed in Section 6). For further details on the five data sets, refer to the Onsite Engineering Report for K103 and K104. The remaining four data sets were used to calculate treatment standards.

The data from the effluent guidelines data base (USEPA 1987a) were evaluated to determine their suitability for establishing treatment standards. Two problems were present that led to the Agency's decision not to use the data in setting BDAT. First, data were not available for all of the constituents of concern in K103 and K104 wastewaters. It is not clear whether other constituents were not present, not detected, or not tested for. When this problem is coupled with the uncertainties of knowledge on the design and operating standards (and the performance), the Agency is reluctant to set regulatory levels for some constituents from one set of data and for other constituents from data from another treatment system.

The second problem may override the first. As noted in the introduction, the BDAT sampling (and enforcement) program is based on "grab" samples. This decision was made early in the program to facilitate a viable and workable approach. For other purposes, the effluent guidelines system, in looking at pollutant load on a stream, is based on composite samples. Even though the values shown in Section 4 are on the same order of magnitude for both systems, it is not appropriate to interchange data from grab samples and data from composite samples. The Agency finds no reason to change its earlier decision to base BDAT levels on grab samples and, in setting standards for K103 and K104, will not use the data provided in New Source Performance Standards for the Organic Chemical, Plastics and Synthetic Fibers Point Source Database.

Toxic Characteristic Leaching Procedure (TCLP) data were not used in setting treatment standards for waste codes K103 and K104 because metals were not one of the classes of BDAT list constituents identified for regulation (see Section 6 for further details). For a discussion on the use of TCLP data in setting treatment standards, refer to Section 1 of this background document.

In instances where a selected constituent was not detected in the treated waste, the treated value for that constituent was assumed to be the Practical Quantification Level. This was the case for the following constituents: (1) benzene in Sample Set 2; (2) aniline in Sample Sets 1, 2, and 4; (3) nitrobenzene in Sample Sets 1, 2, 4, and 5; and (4) phenol in Sample Sets 1, 2, and 4. Analytical values for the treated waste are presented in Section 4, Tables 4-1 through 4-5, of this report.

7.2 Correcting the Remaining Data

Data values for the constituents selected for regulation were taken from the four data sets (Sample Sets 1, 2, 4 and 5). These values were corrected in order to take into account analytical interferences associated with the chemical makeup of the treated sample. This was accomplished by calculating an accuracy factor from the percent recoveries for each selected constituent. The reciprocal of the lower of the two recovery values, divided by 100, yields the accuracy factor. The corrected concentration for each Sample Set is obtained by multiplying the accuracy factor by the uncorrected data value. The calculation of recovery values is described in Section 1 of this background document. The actual recovery values and accuracy factors for the selected constituents are presented in Appendix E.

The accuracy factors calculated for the selected constituents varied from a high value of 4.76 for phenol to a low value of 0.87 for nitrobenzene. The corrected concentration values for the selected constituents are shown for the four data sets in Table 7-1. These corrected concentration values were obtained by multiplying the accuracy factors (Appendix E) by the concentration values for the selected constituents in the treated waste. An arithmetic average value, representing the treated waste concentration, was calculated for each selected constituent from the four corrected values. These averages are presented in Table 7-1.

7.3 Calculating Variability Factors

It is expected that in normal operation of a well-designed and well-operated treatment system there will be some variability in performance. Based on the test data, a measure of this variability is expressed by the variability factor (see Appendix A). These factors were calculated for each of the selected regulated constituents. The methodology for calculating variability factors is explained in Appendix A of this report. Table 7-1 presents the results of calculations for the selected constituents. Appendix D of this report shows how the actual values in Table 7-1 were calculated.

The variability factors calculated for the selected constituents vary from a high value of 15.4 for aniline to a low value of 1.7 for 2,4-dinitrophenol. A variability factor of 1.0 represents test data from a process measured without variation and analytical interferences. Nitrobenzene was not detected in the treated waste, and concentration values for the treated waste were set at the Practical Quantification Level for nitrobenzene. This resulted in no apparent variation among the treated values and a calculated variability factor of 1.0. Instead of using the calculated value of 1.0, the variability factor for nitrobenzene was fixed at 2.8 as justified in Appendix D of this document.

7.4 Calculating the Treatment Standards

The treatment standards for the selected constituents were calculated by multiplying the variability factors by the average concentration values for the treated waste. The treatment standards are presented in Table 7-1. Standards were calculated for wastewaters only. The treatment standards for K103 and K104 nonwastewaters are transferred from the treatment tests of K019 and K048/K051 wastes.

Table 7-1 Regulated Constituents and Calculated Treatment Standards for K103 and K104 Wastewaters

Constituent	Accuracy-Corrected Concentration (mg/l)				Average Treated Waste Concentration (mg/l)	Variability Factor (VF)	Treatment Standard (mg/l) (Average X VF)
	Sample Set #1	Sample Set #2	Sample Set #4	Sample Set #5			
__Volatiles__:							
4. Benzene	0.055	0.007	0.025	0.015	0.026	5.654	0.15
__Semivolatiles__:							
56. Aniline	0.033	0.033	0.033	1.056	0.289	15.398	4.5
101. 2,4-Dinitrophenol*	0.475	0.400	0.325	0.288	0.372	1.648	0.61
126. Nitrobenzene	0.026	0.026	0.026	0.026	0.026	2.800	0.073
142. Phenol	0.143	0.143	0.143	0.714	0.286	4.864	1.4
__Inorganics__:							
169. Total Cyanides**	0.785	0.830	0.217	0.179	0.503	5.334	2.7

* - Percent recovery of 4-Nitrophenol was used in the calculation of the standard for 2,4-Dinitrophenol.

** - Total cyanides are regulated for K104 only.

The BDAT wastewater treatment standard for waste code K103 are as follows:

Constituent	Total composition (mg/l)
Aniline	4.5
Benzene	0.15
2,4-Dinitrophenol	0.61
Nitrobenzene	0.073
Phenol	1.4

The BDAT wastewater treatment standard for waste code K104 are as follows:

Constituent	Total composition (mg/l)
Aniline	4.5
Benzene	0.15
2,4-Dinitrophenol	0.61
Nitrobenzene	0.073
Phenol	1.4
Total Cyanides (CN)	2.7

The treatment standards for waste codes K103 and K104 vary from 4.5 mg/l for aniline to 0.073 mg/l for nitrobenzene.

Nonwastewater treatment standards for waste codes K103 and and K104 were also determined by the Agency. These treatment standards apply to the spent carbon from the carbon adsorber; these treatment standards do not apply to the nitrobenzene solvent extract from the liquid/liquid extractor because the Agency believes that no ash is formed when this stream is incinerated.

As discussed in Section 4, no performance data were available for the treatment of K103 and K104 nonwastewaters. The Agency therefore decided to transfer treatment standards from the treatment of wastes that were determined to be similar to K103 and K104 nonwastewaters based on waste characteristics affecting performance. The nonwastewater treatment standards for waste codes K103 and K104 were transferred from treatment data for wastes K019 and K048/K051. The thermal conductivities of wastes K019, K048, and K051 were compared with the thermal conductivities of waste codes K103 and K104. Waste K019 was selected for transferring treatment standards to wastes K103 and K104 because its thermal conductivity was lower than that of both wastes K103 and K104. The treated waste concentrations and treatment standards for K019 are presented in Table 7-2. The boiling points of the selected constituents in waste codes K103 and K104 were compared with the boiling points of the regulated constituents in waste code K019. Constituents were matched as closely as possible on the basis of the boiling point (see Table 7-2).

Chlorinated organic constituents in K019 with three or more chlorine atoms in their structure were eliminated from consideration for this matching. All chlorinated organics with three or more chlorine atoms were below detectable levels in treated K019. The treated concentrations were therefore set at the detection limit for these constituents. However, the detection limits for these constituents were abnormally high in treated K019 because of matrix interferences, leading to high treatment standards. Therefore, chlorinated organic constituents with three or more chlorine atoms were not considered when matching constituents from K103 and K104 with those from K019. The remaining constituents in K019 were matched as closely as possible with those in

Table 7-2 Regulated Constituents and Calculated Treatment Standards for K019 Nonwastewaters[2]

Constituent	Treated Waste Concentration Range (mg/kg)	Average Treated Waste Concentration (mg/kg)	Variability Factor (VF)	Treatment Standard (mg/kg) (Average X VF)	Boiling Point (deg. C)
Volatiles:					
9. Chlorobenzene	<2	2.14	2.8	6.0	132
14. Chloroform	<2	2.14	2.8	6.0	61.7
23. 1,2-Dichloroethane	<2	2.14	2.8	6.0	83.5
Semivolatiles:					
68. Bis(2-chloroethyl)ether	<2	2.0	2.8	5.6	116
121. Naphthalene	<2	2.0	2.8	5.6	218
141. Phenanthrene	<2	2.0	2.8	5.6	340

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[2] - Treatment standard calculations are described in detail in the Background Document for K019.

K103 and K104 on the basis of boiling point.* Treatment standards were then transferred from waste code K019 to the matched constituent. Cyanide treatment standards were transferred from the treatment of K048/K051, since cyanide was not present in K019 waste.

The BDAT nonwastewater treatment standards for waste codes K103 and K104 are as follows:

Constituent	Total composition (mg/kg)	
	K103	K104
Aniline	5.6	5.6
Benzene	6.0	6.0
2,4-Dinitrophenol	5.6	5.6
Nitrobenzene	5.6	5.6
Phenol	5.6	5.6
Total Cyanides (CN)	NR	1.8

NR - Not regulated for this waste code.

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* The removal of highly chlorinated organic constituents in K019 from consideration for transfer affected the treatment standards for the following constituents in K103 and K104: nitrobenzene (naphthalene was used rather than 1,2,4-tri- chlorobenzene), aniline, and phenol (naphthalene was used rather than hexachloroethane or 1,2,4-trichlorobenzene).

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APPENDIX A

STATISTICAL METHODS

A.1 F Value Determination for ANOVA Test

As noted in Section 1.2, EPA is using the statistical method known as analysis of variance (ANOVA) to determine the level of performance that represents "best" treatment where more than one technology is demonstrated. This method provides a measure of the differences between data sets.

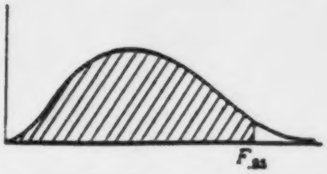
If the Agency found that the levels of performance for one or more technologies are not statistically different (i.e., the data sets are homogeneous), EPA would average the long-term performance values achieved by each technology and then multiply this value by the largest variability factor associated with any of the acceptable technologies. If EPA found that one technology performs significantly better (i.e., the data sets are not homogeneous), the "best" technology would be the technology that achieves the best level of performance, i.e.. the technology with the lowest mean value.

To determine whether any or all of the treatment performance data sets are homogeneous using the analysis of variance method, it is necessary to compare a calculated "F value" to what is known as a "critical value." (See Table A-1.) These critical values are available in most statistics texts (see, for example, Statistical Concepts and Methods by Bhattacharyya and Johnson, 1977, John Wiley Publications, New York).

Table A-1

95th PERCENTILE VALUES FOR THE *F* DISTRIBUTION

n_1 = degrees of freedom for numerator
n_2 = degrees of freedom for denominator
(shaded area = .95)



n_2 \ n_1	1	2	3	4	5	6	8	12	16	20	30	40	50	100	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	238.9	243.9	246.3	248.0	250.1	251.1	252.2	253.0	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.37	19.41	19.43	19.45	19.46	19.46	19.47	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.85	8.74	8.69	8.66	8.62	8.60	8.58	8.56	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.04	5.91	5.84	5.80	5.75	5.71	5.70	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.82	4.68	4.60	4.56	4.50	4.46	4.44	4.40	4.36
6	5.99	5.14	4.76	4.53	4.39	4.28	4.15	4.00	3.92	3.87	3.81	3.77	3.75	3.71	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.73	3.57	3.49	3.44	3.38	3.34	3.32	3.28	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.44	3.28	3.20	3.15	3.08	3.05	3.03	2.98	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.23	3.07	2.98	2.93	2.86	2.82	2.80	2.76	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.07	2.91	2.82	2.77	2.70	2.67	2.64	2.59	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	2.95	2.79	2.70	2.65	2.57	2.53	2.50	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.85	2.69	2.60	2.54	2.46	2.42	2.40	2.35	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.77	2.60	2.51	2.46	2.38	2.34	2.32	2.26	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.70	2.53	2.44	2.39	2.31	2.27	2.24	2.19	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.64	2.48	2.39	2.33	2.25	2.21	2.18	2.12	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.59	2.42	2.33	2.28	2.20	2.16	2.13	2.07	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.55	2.38	2.29	2.23	2.15	2.11	2.08	2.02	1.96
18	4.41	3.55	3.16	2.93	2.77	2.66	2.51	2.34	2.25	2.19	2.11	2.07	2.04	1.98	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.48	2.31	2.21	2.15	2.07	2.02	2.00	1.94	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.45	2.28	2.18	2.12	2.04	1.99	1.96	1.90	1.84
22	4.30	3.44	3.05	2.82	2.66	2.55	2.40	2.23	2.13	2.07	1.98	1.93	1.91	1.84	1.78
24	4.26	3.40	3.01	2.78	2.62	2.51	2.36	2.18	2.09	2.03	1.94	1.89	1.86	1.80	1.73
26	4.23	3.37	2.98	2.74	2.59	2.47	2.32	2.15	2.05	1.99	1.90	1.85	1.82	1.76	1.69
28	4.20	3.34	2.95	2.71	2.56	2.45	2.29	2.12	2.02	1.96	1.87	1.81	1.78	1.72	1.65
30	4.17	3.32	2.92	2.69	2.53	2.42	2.27	2.09	1.99	1.93	1.84	1.79	1.76	1.69	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.18	2.00	1.90	1.84	1.74	1.69	1.66	1.59	1.51
50	4.03	3.18	2.79	2.56	2.40	2.29	2.13	1.95	1.85	1.78	1.69	1.63	1.60	1.52	1.44
60	4.00	3.15	2.76	2.53	2.37	2.25	2.10	1.92	1.81	1.75	1.65	1.59	1.56	1.48	1.39
70	3.98	3.13	2.74	2.50	2.35	2.23	2.07	1.89	1.79	1.72	1.62	1.56	1.53	1.45	1.35
80	3.96	3.11	2.72	2.48	2.33	2.21	2.05	1.88	1.77	1.70	1.60	1.54	1.51	1.42	1.32
100	3.94	3.09	2.70	2.46	2.30	2.19	2.03	1.85	1.75	1.68	1.57	1.51	1.48	1.39	1.28
150	3.91	3.06	2.67	2.43	2.27	2.16	2.00	1.82	1.71	1.64	1.54	1.47	1.44	1.34	1.22
200	3.89	3.04	2.65	2.41	2.26	2.14	1.98	1.80	1.69	1.62	1.52	1.45	1.42	1.32	1.19
400	3.86	3.02	2.62	2.39	2.23	2.12	1.96	1.78	1.67	1.60	1.49	1.42	1.38	1.28	1.13
∞	3.84	2.99	2.60	2.37	2.21	2.09	1.94	1.75	1.64	1.57	1.46	1.40	1.32	1.24	1.00

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Where the F value is less than the critical value, all treatment data sets are homogeneous. If the F value exceeds the critical value, it is necessary to perform a "pair wise F" test to determine if any of the sets are homogeneous. The "pair wise F" test must be done for all of the various combinations of data sets using the same method and equation as the general F test.

The F value is calculated as follows:

(i) All data are natural logtransformed.

(ii) The sum of the data points for each data set is computed (T_i).

(iii) The statistical parameter known as the sum of the squares between data sets (SSB) is computed:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

where:

k = number of treatment technologies
n_i = number of data points for technology i
N = number of data points for all technologies
T_i = sum of natural logtransformed data points for each technology.

(iv) The sum of the squares within data sets (SSW) is computed:

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

where:

$x_{i,j}$ = the natural logtransformed observations (j) for treatment technology (i).

(v) The degrees of freedom corresponding to SSB and SSW are calculated. For SSB, the degree of freedom is given by k-1. For SSW, the degree of freedom is given by N-k.

(vi) Using the above parameters, the F value is calculated as follows:

$$F = \frac{MSB}{MSW}$$

where:

$MSB = SSB/(k-1)$ and
$MSW = SSW/(N-k)$.

A computational table summarizing the above parameters is shown below.

Computational Table for the F Value

Source	Degrees of freedom	Sum of squares	Mean square	F value
Between	k-1	SSB	MSB = SSB/k-1	MSB/MSW
Within	N-k	SSW	MSW = SSW/N-k	

Below are three examples of the ANOVA calculation. The first two represent treatment by different technologies that achieve statistically similar treatment; the last example represents a case in which one technology achieves significantly better treatment than the other technology.

Example 1
Methylene Chloride

Steam stripping				Biological treatment			
Influent (μg/l)	Effluent (μg/l)	ln(effluent)	[ln(effluent)]^2	Influent (μg/l)	Effluent (μg/l)	ln(effluent)	[ln(effluent)]^2
1550.00	10.00	2.30	5.29	1960.00	10.00	2.30	5.29
1290.00	10.00	2.30	5.29	2568.00	10.00	2.30	5.29
1640.00	10.00	2.30	5.29	1817.00	10.00	2.30	5.29
5100.00	12.00	2.48	6.15	1640.00	26.00	3.26	10.63
1450.00	10.00	2.30	5.29	3907.00	10.00	2.30	5.29
4600.00	10.00	2.30	5.29				
1760.00	10.00	2.30	5.29				
2400.00	10.00	2.30	5.29				
4800.00	10.00	2.30	5.29				
12100.00	10.00	2.30	5.29				
Sum:							
-	-	23.18	53.76	-	-	12.46	31.79
Sample Size:							
10	10	10	-	5	5	5	
Mean:							
3669	10.2	2.32	-	2378	13.2	2.49	-
Standard Deviation:							
3328.67	.63	.06	-	923.04	7.15	.43	-
Variability Factor:							
	1.15	-	-	-	2.48	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^{\,2}}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2{}_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i{}^2}{n_i} \right)$$

MSB = SSB/(k-1)

MSW = SSW/(N-k)

Example 1 (Continued)

$F = MSB/MSW$

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of natural logtransformed data points for all technologies

T_i = sum of logtransformed data points for each technology

X_{ij} - the nat. logtransformed observations (j) for treatment technology (i)

$n_1 = 10,\ n_2 = 5,\ N = 15,\ k = 2,\ T_1 = 23.18,\ T_2 = 12.46,\ T = 35.64,\ T^2 = 1270.21$

$T_1^2 = 537.31 \quad T_2^2 = 155.25$

$$SSB = \left(\frac{537.31}{10} + \frac{155.25}{5}\right) - \frac{1270.21}{15} = 0.10$$

$$SSW = (53.76 + 31.79) - \left(\frac{537.31}{10} + \frac{155.25}{5}\right) = 0.77$$

$MSB = 0.10/1 = 0.10$

$MSW = 0.77/13 = 0.06$

$$F = \frac{0.10}{0.06} = 1.67$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.10	0.10	1.67
Within(W)	13	0.77	0.06	

The critical value of the F test at the 0.05 significance level is 4.67. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 2
Trichloroethylene

	Steam stripping				Biological treatment		
Influent (µg/l)	Effluent (µg/l)	ln(effluent)	$[\ln(\text{effluent})]^2$	Influent (µg/l)	Effluent (µg/l)	ln(effluent)	$[\ln(\text{effluent})]^2$
1650.00	10.00	2.30	5.29	200.00	10.00	2.30	5.29
5200.00	10.00	2.30	5.29	224.00	10.00	2.30	5.29
5000.00	10.00	2.30	5.29	134.00	10.00	2.30	5.29
1720.00	10.00	2.30	5.29	150.00	10.00	2.30	5.29
1560.00	10.00	2.30	5.29	484.00	16.25	2.79	7.78
10300.00	10.00	2.30	5.29	163.00	10.00	2.30	5.29
210.00	10.00	2.30	5.29	182.00	10.00	2.30	5.29
1600.00	27.00	3.30	10.89				
204.00	85.00	4.44	19.71				
160.00	10.00	2.30	5.29				
Sum:							
-	-	26.14	72.92	-	-	16.59	39.52
Sample Size:							
10	10	10	-	7	7	7	-
Mean:							
2760	19.2	2.61	-	220	10.89	2.37	-
Standard Deviation:							
3209.6	23.7	.71	-	120.5	2.36	.19	-
Variability Factor:							
-	3.70	-	-	-	1.53	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2_{i,j} \right] - \sum_{i=1}^{k} \left(\frac{T_i^2}{n_i} \right)$$

$$MSB = SSB/(k-1)$$

$$MSW = SSW/(N-k)$$

Example 2 (Continued)

F = MSB/MSW

where:

k = number of treatment technologies

n_i = number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

X_{ij} = the natural logtransformed observations (j) for treatment technology (i)

$N_1 = 10,\ N_2 = 7,\ N = 17,\ k = 2,\ T_1 = 26.14,\ T_2 = 16.59,\ T = 42.73,\ T^2 = 1825.85,\ T_1^2 = 683.30,$

$T_2^2 = 275.23$

$$SSB = \left[\frac{683.30}{10} + \frac{275.23}{7}\right] - \frac{1825.85}{17} = 0.25$$

$$SSW = (72.92 + 39.52) - \left[\frac{683.30}{10} + \frac{275.23}{7}\right] = 4.79$$

MSB = 0.25/1 = 0.25

MSW = 4.79/15 = 0.32

$$F = \frac{0.25}{0.32} = 0.78$$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	0.25	0.25	0.78
Within(W)	15	4.79	0.32	

The critical value of the F test at the 0.05 significance level is 4.54. Since the F value is less than the critical value, the means are not significantly different (i.e., they are homogeneous).

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

Example 3
Chlorobenzene

Activated sludge followed by carbon adsorption				Biological treatment			
Influent (μg/l)	Effluent (μg/l)	ln(effluent)	[ln(effluent)]^2	Influent (μg/l)	Effluent (μg/l)	ln(effluent)	ln[(effluent)]^2
7200.00	80.00	4.38	19.18	9206.00	1083.00	6.99	48.86
6500.00	70.00	4.25	18.06	16646.00	709.50	6.56	43.03
6075.00	35.00	3.56	12.67	49775.00	460.00	6.13	37.58
3040.00	10.00	2.30	5.29	14731.00	142.00	4.96	24.60
				3159.00	603.00	6.40	40.96
				6756.00	153.00	5.03	25.30
				3040.00	17.00	2.83	8.01
Sum:							
-	-	14.49	55.20	-	-	38.90	228.34
Sample Size:							
4	4	4	-	7	7	7	-
Mean:							
5703	49	3.62	-	14759	452.5	5.56	-
Standard Deviation:							
1835.4	32.24	.95		16311.86	379.04	1.42	
Variability Factor:							
-	7.00	-	-	-	15.79	-	-

ANOVA Calculations:

$$SSB = \left[\sum_{i=1}^{k} \left(\frac{T_i^{\,2}}{n_i} \right) \right] - \left[\frac{\left(\sum_{i=1}^{k} T_i \right)^2}{N} \right]$$

$$SSW = \left[\sum_{i=1}^{k} \sum_{j=1}^{n_i} x^2{}_{i,j} \right] \sum_{i=1}^{k} \left(\frac{T_i{}^2}{n_i} \right)$$

MSB = SSB/(k-1)

MSW = SSW/(N-k)

F = MSB/MSW

Example 3 (Continued)

where,

k = number of treatment technologies

n_i - number of data points for technology i

N = number of data points for all technologies

T_i = sum of natural logtransformed data points for each technology

X_{ij} - the natural logtransformed observations (j) for treatment technology (i)

$N_1 = 4$, $N_2 = 7$, $N = 11$, $k = 2$, $T_1 = 14.49$, $T_2 = 38.90$, $T = 53.39$, $T^2 = 2850.49$, $T_1^2 = 209.96$

$T_2^2 = 1513.21$

$$SSB = \left[\frac{209.96}{4} + \frac{1513.21}{7}\right] - \frac{2850.49}{11} = 9.52$$

$$SSW = (55.20 + 228.34) - \left(\frac{209.96}{4} + \frac{1513.21}{7}\right) = 14.88$$

$MSB = 9.52/1 = 9.52$

$MSW = 14.88/9 = 1.65$

$F = 9.52/1.65 = 5.77$

ANOVA Table

Source	Degrees of freedom	SS	MS	F value
Between(B)	1	9.53	9.53	5.77
Within(W)	9	14.89	1.65	

The critical value of the F test at the 0.05 significance level is 5.12. Since the F value is larger than the critical value, the means are significantly different (i.e., they are heterogeneous). Activated sludge followed by carbon adsorption is "best" in this example because the mean of the long-term performance value, i.e., the effluent concentration, is lower.

Note: All calculations were rounded to two decimal places. Results may differ depending upon the number of decimal places used in each step of the calculations.

A.2 Variability Factor

$$VF = \frac{C_{99}}{Mean}$$

where:

VF = estimate of daily maximum variability factor determined from a sample population of daily data;

C_{99} = estimate of performance values for which 99 percent of the daily observations will be below. C_{99} is calculated using the following equation: $C_{99} = Exp(y + 2.33\ Sy)$ where y and Sy are the mean and standard deviation, respectively, of the logtransformed data; and

Mean = average of the individual performance values.

EPA is establishing this figure as an instantaneous maximum because the Agency believes that on a day-to-day basis the waste should meet the applicable treatment standards. In addition, establishing this requirement makes it easier to check compliance on a single day. The 99th percentile is appropriate because it accounts for almost all process variability.

In several cases, all the results from analysis of the residuals from BDAT treatment are found at concentrations less than the detection limit. In such cases, all the actual concentration values are considered unknown and, hence, cannot be used to estimate the variability factor of the analytical results. Below is a description of EPA's approach for calculating the variability factor for such cases with all concentrations below the detection limit.

It has been postulated as a general rule that a lognormal distribution adequately describes the variation among concentrations. Agency data show that the treatment residual concentrations are distributed approximately lognormally. Therefore, the lognormal model has been used routinely in the EPA development of numerous regulations in the Effluent Guidelines program and is being used in the BDAT program. The variability factor (VF) was defined as the ratio of the 99th percentile (C_{99}) of the lognormal distribution to its arithmetic mean (Mean), as follows:

$$VF = \frac{C_{99}}{\text{Mean}}. \tag{1}$$

The relationship between the parameters of the lognormal distribution and the parameters of the normal distribution created by taking the natural logarithms of the lognormally distributed concentrations can be found in most mathematical statistics texts (see, for example, Distribution in Statistics-Volume 1 by Johnson and Kotz, 1970). The mean of the lognormal distribution can be expressed in terms of the mean (μ) and standard deviation (σ) of the normal distribution as follows:

$$C_{99} = \text{Exp}\ (\mu + 2.33\sigma) \tag{2}$$

$$\text{Mean} = \text{Exp}\ (\mu + 0.5\sigma^2). \tag{3}$$

By substituting (2) and (3) in (1), the variability factor can then be expressed in terms of σ as follows:

$$VF = \text{Exp}\ (2.33\ \sigma - 0.5\sigma^2). \tag{4}$$

For residuals with concentrations that are not all below the detection limit, the 99th percentile and the mean can be estimated from the actual analytical data and, accordingly, the variability factor (VF) can be estimated using equation (1). For residuals with concentrations that are below the detection limit, the above equations can be used in conjunction with the following assumptions to develop a variability factor.

- Assumption 1: The actual concentrations follow a lognormal distribution. The upper limit (UL) is equal to the detection limit. The lower limit (LL) is assumed to be equal to one-tenth of the detection limit. This assumption is based on the fact that data from well-designed and well-operated treatment systems generally fall within one order of magnitude.
- Assumption 2: The natural logarithms of the concentrations have a normal distribution with an upper limit equal to ln (UL) and a lower limit equal to ln (LL).
- Assumption 3: The standard deviation (σ) of the normal distribution is approximated by:

$$\sigma = [\ln(UL) - \ln(LL)] / [(2)(2.33)]$$
$$= [\ln(UL/LL)] / 4.66. \qquad (5)$$

(Note that when LL = (0.1)(UL) as in Assumption 1, then $\sigma = (\ln 10) / 4.66 = 0.494$.)

Substitution of the σ value from equation (5) into equation (4) yields the variability factor, VF, as shown:

$$VF = 2.8. \qquad (6)$$

APPENDIX B

ANALYSIS OF VARIANCE TESTS

ANOVA #1

Comparison of L/L Extraction with L/L Extraction Followed by Steam Stripping

Compare sample point SD-5 (Untreated Waste to Steam Stripper) with sample point SD-6 (Treated Waste From Steam Stripper)

Regulated Constituents:
Benzene
Nitrobenzene
2,4-Dinitrophenol
Phenol
Aniline
Cyanide

Regulated Constituents Present in Untreated Waste (SD-5):

Benzene
Nitrobenzene
Cyanide

Regulated Constituents Present in Treated Waste (SD-6):

Benzene
2,4-Dinitrophenol (*)
Cyanide

* - An ANOVA analysis could not be completed on this constituent, since no information is available on the concentration of this constituent in the untreated waste (SD-5).

1) Benzene (ug/l)
AF = 1.32

		1	2	4	5
Raw	SD-5	170,000	190,000	26,000	17,000
Corr.	SD-5	224,400	250,800	34,320	22,440
Raw	SD-6	(5)	8	(5)	(5)
Corr.	SD-6	6.6	10.6	6.6	6.6

2) Nitrobenzene (ug/l)
AF = 0.87

		1	2	4	5
Raw	SD-5	$2.3\text{x}10^6$	$2.8\text{x}10^6$	$2.0\text{x}10^6$	$2.0\text{x}10^6$
Corr.	SD-5	$2.0\text{x}10^6$	$2.4\text{x}10^6$	$1.7\text{x}10^6$	$1.7\text{x}10^6$
Raw	SD-6	(3000)	(3000)	(1500)	(3000)
Corr.	SD-6	2610	2610	1305	2610

3) Cyanide (mg/l)
AF = 1.39

		1	2	4	5
Raw	SD-5	4.36	3.45	2.54	2.27
Corr.	SD-5	6.06	4.80	3.53	3.16
Raw	SD-6	4.77	3.87	2.08	1.70
Corr.	SD-6	6.63	5.38	2.89	2.36

Note: Numbers in parentheses indicate that the compound was not detected in this sample. The detection limit has been used in place of the actual value for this compound.

(Above raw values are taken from the EPA's Onsite Engineering Report for K103 and K104, Tables 6-10 and 6-11).

1) Benzene

	Treatment 1	Treatment 2	x_1	x_2
SS1	224,400	6.6	12.32	1.89
SS2	250,800	10.6	12.43	2.36
SS4	34,320	6.6	10.44	1.89
SS5	22,440	6.6	10.02	1.89

$k = 2$
$n_1 = 4 \quad n_2 = 4$
$N = 8$

$$\begin{aligned} SSB &= (T_1{}^2/n_1 + T_2{}^2/n_2) - T^2/N \\ &= (2043.94/4 + 64.48/4) - 2834.5/8 \\ &= (510.99 + 16.12) - 354.31 \\ &= 527.11 - 354.31 \\ &= 172.80 \end{aligned}$$

$MSB = SSB/k-1 = 172.80/1 = 172.80$

$$\begin{aligned} SSW &= \hat{E}\,\hat{E}\, x_{i,j}{}^2 - 527.11 \\ &= 531.97 - 527.11 \\ &= 4.86 \end{aligned}$$

$MSW = SSW/N-k = 4.86/6 = 0.81$

$F = MSB/MSW = 172.80/0.81 = 213.3$

$F_{k-1,N-k} = F_{1,6} = 5.99$ (critical value for 95% confidence)

2) Nitrobenzene

	Treatment 1	Treatment 2	x_1	x_2
SS1	2.00×10^6	2610	14.51	7.87
SS2	2.44×10^6	2610	14.71	7.87
SS4	1.74×10^6	1305	14.37	7.17
SS5	1.74×10^6	2610	14.37	7.87

$k = 2$
$n_1 = 4 \quad n_2 = 4$
$N = 8$

$$
\begin{aligned}
SSB &= (T_1^2/n_1 + T_2^2/n_2) - T^2/N \\
&= (3359.36/4 + 947.41/4) - 7874.79/8 \\
&= (839.84 + 236.85) - 984.35 \\
&= 1076.69 - 984.35 \\
&= 92.34
\end{aligned}
$$

$MSB = SSB/k-1 = 92.34/1 = 92.34$

$$
\begin{aligned}
SSW &= \hat{E}\,\hat{E}\, x_{i,j}^2 - 1076.69 \\
&= 1077.14 - 1076.69 \\
&= .45
\end{aligned}
$$

$MSW = SSW/N-k = 0.45/6 = 0.08$

$F = MSB/MSW = 92.34/0.08 = 1154.25$

$F_{k-1,N-k} = F_{1,6} = 5.99$ (critical value for 95% confidence)

3) Cyanide

	Treatment 1	Treatment 2	x_1	x_2
SS1	6.06	6.63	1.80	1.89
SS2	4.80	5.38	1.57	1.68
SS4	3.53	2.89	1.26	1.06
SS5	3.16	2.36	1.15	0.86

$k = 2$
$n_1 = 4 \quad n_2 = 4$
$N = 8$

$$
\begin{aligned}
SSB &= (T_1^2/n_1 + T_2^2/n_2) - T^2/N \\
&= (33.41/4 + 30.14/4) - 127.01/8 \\
&= (8.35 + 7.54) - 15.88 \\
&= 15.89 - 15.88 \\
&= 0.01
\end{aligned}
$$

$MSB = SSB/k-1 = 0.01/1 = 0.01$

$$
\begin{aligned}
SSW &= \hat{E}\,\hat{E}\, x_{i,j}^2 - 15.89 \\
&= 16.87 - 15.89 \\
&= 0.98
\end{aligned}
$$

$MSW = SSW/N-k = 0.98/6 = 0.16$

$F = MSB/MSW = 0.01/0.16 = 0.06$

$F_{k-1,N-k} = F_{1,6} = 5.99$ (critical value for 95% confidence)

Computational Table for the F Value

Constituent	Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Benzene	Between	172.80	1	172.80	213.3*
	Within	4.86	6	0.81	
Nitrobenzene	Between	92.34	1	92.34	1154.25*
	Within	0.45	6	0.08	
Total Cyanides	Between	0.01	1	0.01	0.06
	Within	0.98	6	0.16	

* - Indicates that the calculated F value exceeds the critical value.

Conclusion

L/L Extraction followed by steam stripping is more efficient at reducing the concentration of benzene and nitrobenzene in K103/K104 than L/L extraction alone, but is not more efficient at reducing the concentration of total cyanides in K103/K104 than L/L extraction alone.

ANOVA #2

Comparison of L/L Extraction Followed by Steam Stripping with L/L Extraction Followed by Steam Stripping Followed by Activated Carbon Adsorption

Compare sample point SD-8 (Untreated Waste to Activated Carbon Adsorption Beds) with sample point SD-9 (Treated Waste from Carbon Adsorption System)

Regulated Constituents:
- Benzene
- Nitrobenzene
- 2,4-Dinitrophenol
- Phenol
- Aniline
- Cyanide

Regulated Constituents Present in Untreated Waste (SD-8):

- Benzene
- Aniline
- 2,4-Dinitrophenol
- Phenol
- Cyanide

Regulated Constituents Present in Treated Waste (SD-9):

- Benzene
- Aniline
- 2,4-Dinitrophenol
- Phenol
- Cyanide

1) Benzene (ug/l)
AF = 1.32

		1	2	4	5
Raw	SD-8	880	130	39	20
Corr.	SD-8	1161.60	171.60	51.48	26.40
Raw	SD-9	42	(5)	19	11
Corr.	SD-9	55.44	6.6	25.08	14.52

2) Aniline (ug/l)
AF = 1.10

		1	2	4	5
Raw	SD-8	57000	ND	56000	300000
Corr.	SD-8	62700	ND	61600	330000
Raw	SD-9	(30)	(30)	(30)	960
Corr.	SD-9	33	33	33	1056

3) 2,4-Dinitrophenol (ug/l)
AF = 1.25

		1	2	4	5
Raw	SD-8	53000	ND	24000	24000
Corr.	SD-8	66250	ND	30000	30000
Raw	SD-9	380	320	260	230
Corr.	SD-9	475	400	325	288

Note: Numbers in parentheses indicate that the compound was not detected in this sample. The detection limit has been used in place of the actual value for this compound. "ND" indicates that this compound was not detected in the untreated waste (SD-8), and hence this reading was not used in the ANOVA calculations.

4) Phenol (ug/l)
AF = 4.76

		1	2	4	5
Raw	SD-8	ND	29000	39000	41000
Corr.	SD-8	ND	138040	185640	195160
Raw	SD-9	(30)	(30)	(30)	150
Corr.	SD-9	142.8	142.8	142.8	714

5) Cyanide (mg/l)
AF = 1.39

		1	2	4	5
Raw	SD-8	6.850	4.590	3.470	0.952
Corr.	SD-8	9.52	6.38	4.82	1.32
Raw	SD-9	0.565	0.597	0.156	0.129
Corr.	SD-9	0.79	0.83	0.22	0.18

Note: Numbers in parentheses indicate that the compound was not detected in this sample. The detection limit has been used in place of the actual value for this compound. "ND" indicates that this compound was not detected in the untreated waste (SD-8), and hence this reading was not used in the ANOVA calculations.

(Above raw values are taken from the EPA's Onsite Engineering Report for K103 and K104, Tables 6-13 and 6-14).

1) Benzene

	Treatment 1	Treatment 2	x_1	x_2
SS1	1161.6	55.4	7.06	4.01
SS2	171.6	6.6	5.15	1.89
SS4	51.5	25.1	3.94	3.22
SS5	26.4	14.5	3.27	2.67

$k = 2$
$n_1 = 4$ $n_2 = 4$
$N = 8$

$SSB = (T_1^2/n_1 + T_2^2/n_2) - T^2/N$
$= (377.14/4 + 139.00/4) - 974.06/8$
$= (94.29 + 34.75) - 121.76$
$= 129.04 - 121.76$
$= 7.28$

$MSB = SSB/k-1 = 7.28/1 = 7.28$

SSW = Ê Ê $x_{i,j}^2 - 129.04$
$= 139.73 - 129.04$
$= 10.69$

$MSW = SSW/N-k = 10.69/6 = 1.78$

$F = MSB/MSW = 7.28/1.78 = 4.09$

$F_{k-1,N-k} = F_{1,6} = 5.99$ (critical value for 95% confidence)

2) Aniline

	Treatment 1	Treatment 2	x_1	x_2
SS1	62700	33	11.05	3.50
SS2	ND	33	ND	3.50
SS4	61600	33	11.03	3.50
SS5	330000	1056	12.71	6.96

$k = 2$
$n_1 = 3 \quad n_2 = 4$
$N = 7$

$$
\begin{aligned}
SSB &= (T_1^2/n_1 + T_2^2/n_2) - T^2/N \\
&= (1210.34/3 + 304.85/4) - 2730.06/7 \\
&= (403.45 + 76.21) - 390.01 \\
&= 479.66 - 390.01 \\
&= 89.65
\end{aligned}
$$

$MSB = SSB/k-1 = 89.65/1 = 89.65$

$$
\begin{aligned}
SSW &= \hat{E}\ \hat{E}\ x_{i,j}^2 - 479.66 \\
&= 490.49 - 479.66 \\
&= 10.83
\end{aligned}
$$

$MSW = SSW/N-k = 10.83/5 = 2.17$

$F = MSB/MSW = 89.65/2.17 = 41.31$

$F_{k-1,N-k} = F_{1,5} = 6.61$ (critical value for 95% confidence)

3) 2,4-Dinitrophenol

	Treatment 1	Treatment 2	x_1	x_2
SS1	66250	475	11.10	6.16
SS2	ND	400	ND	5.99
SS4	30000	325	10.31	5.78
SS5	30000	288	10.31	5.66

$k = 2$
$n_1 = 3 \quad n_2 = 4$
$N = 7$

$$\begin{aligned} SSB &= (T_1^2/n_1 + T_2^2/n_2) - T^2/N \\ &= (1006.16/3 + 556.49/4) - 3059.20/7 \\ &= (335.39 + 139.12) - 437.03 \\ &= 474.51 - 437.03 \\ &= 37.48 \end{aligned}$$

$MSB = SSB/k-1 = 37.48/1 = 37.48$

$$\begin{aligned} SSW &= \text{Ê Ê}\ x_{i,j}^2 - 474.51 \\ &= 475.07 - 474.51 \\ &= 0.56 \end{aligned}$$

$MSW = SSW/N-k = 0.56/5 = 0.11$

$F = MSB/MSW = 37.48/0.11 = 340.73$

$F_{k-1,N-k} = F_{1,5} = 6.61$ (critical value for 95% confidence)

4) Phenol

	Treatment 1	Treatment 2	x_1	x_2
SS1	ND	142.8	ND	4.96
SS2	138040	142.8	11.84	4.96
SS4	185640	142.8	12.13	4.96
SS5	195160	714.0	12.18	6.57

$k = 2$
$n_1 = 3 \quad n_2 = 4$
$N = 7$

$$\begin{aligned} SSB &= (T_1^2/n_1 + T_2^2/n_2) - T^2/N \\ &= (1306.82/3 + 460.10/4) - 3317.76/7 \\ &= (435.61 + 115.02) - 473.97 \\ &= 550.63 - 473.97 \\ &= 76.66 \end{aligned}$$

$MSB = SSB/k-1 = 76.66/1 = 76.66$

$$\begin{aligned} SSW &= \Sigma\,\Sigma\, x_{i,j}^2 - 550.63 \\ &= 552.64 - 550.63 \\ &= 2.01 \end{aligned}$$

$MSW = SSW/N-k = 2.01/5 = 0.40$

$F = MSB/MSW = 76.66/0.40 = 191.65$

$F_{k-1,N-k} = F_{1,5} = 6.61$ (critical value for 95% confidence)

5) Cyanide

	Treatment 1	Treatment 2	x_1	x_2
SS1	9.52	0.79	2.25	-0.24
SS2	6.38	0.83	1.85	-0.19
SS4	4.82	0.22	1.57	-1.51
SS5	1.32	0.18	0.28	-1.71

$k = 2$
$n_1 = 4 \quad n_2 = 4$
$N = 8$

$SSB = (T_1^2/n_1 + T_2^2/n_2) - T^2/N$
$= (35.4/4 + 13.3/4) - 5.29/8$
$= (8.85 + 3.33) - 0.66$
$= 12.18 - 0.66$
$= 11.52$

$MSB = SSB/k-1 = 11.52/1 = 11.52$

$SSW = \hat{E}\,\hat{E}\, x_{i,j}^2 - 12.18$
$= 16.33 - 12.18$
$= 4.15$

$MSW = SSW/N-k = 4.15/6 = 0.69$

$F = MSB/MSW = 11.52/0.69 = 16.70$

$F_{k-1,N-k} = F_{1,6} = 5.99$ (critical value for 95% confidence)

Computational Table for the F Value

Constituent	Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Benzene	Between	7.28	1	7.28	4.09
	Within	10.69	6	1.78	
Aniline	Between	89.65	1	89.65	41.31*
	Within	10.83	5	2.17	
2,4-Dinitrophenol	Between	37.48	1	37.48	340.73*
	Within	0.56	5	0.11	
Phenol	Between	76.66	1	76.66	191.65*
	Within	2.01	5	0.40	
Total Cyanides	Between	11.52	1	11.52	16.70*
	Within	4.15	6	0.69	

* - Indicates that the calculated F value exceeds the critical value.

Conclusion

L/L extraction followed by steam stripping and activated carbon adsorption is more efficient at reducing the concentration of aniline, 2,4-dinitrophenol, phenol and cyanide in K103/K104 than L/L extraction followed by steam stripping alone, but is not more efficient at reducing the concentration of benzene in K103/K104 than L/L extraction followed by steam stripping alone.

APPENDIX C

DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE

The following tables show detection limits for the BDAT list constituents in the untreated and treated K103/K104 wastes.

APPENDIX C - DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE

SAMPLE SET 1

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	VOLATILE ORGANICS(ug/L)			
1	Acetonitrile	10000	10000	100
2	Acrolein	10000	10000	100
3	Acrylonitrile	10000	10000	100
4	Benzene	500	500	5
5	Bromodichloromethane	500	500	5
6	Bromomethane	1000	1000	10
7	Carbon Tetrachloride	500	500	5
8	Carbon Disulfide	500	500	5
9	Chlorobenzene	500	500	5
10	2-Chloro-1,3-Butadiene	10000	10000	100
11	Chlorodibromomethane	500	500	5
12	Chloroethane	1000	1000	10
13	2-Chloroethylvinylether	1000	1000	10
14	Chloroform	500	500	5
15	Chloromethane	1000	1000	10
16	3-Chloropropene	10000	10000	100
17	1,2-Dibromo-3-Chloropropane	1000	1000	10
18	1,2-Dibromoethane	500	500	5
19	Dibromomethane	500	500	5
20	Trans-1,4-Dichloro-2-Butene	10000	10000	100
21	Dichlorodifluoromethane	1000	1000	10
22	1,1-Dichloroethane	500	500	5
23	1,2-Dichloroethane	500	500	5
24	1,1-Dichloroethene	500	500	5
25	Trans-1,2-Dichloroethene	500	500	5
26	1,2-Dichloropropane	500	500	5
27	Trans-1,3-Dichloropropene	500	500	5
28	cis-1,3,Dichloropropene	500	500	5
29	1,4-Dioxane	20000	20000	200
30	Ethyl Cyanide	10000	10000	100
31	Ethyl Methacrylate	10000	10000	100
32	Iodomethane	5000	5000	50
33	Isobutyl Alcohol	20000	20000	200
34	Methyl ethyl ketone	10000	10000	100
35	Methyl Methacrylate	10000	10000	100

(Continued)

APPENDIX C   DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 1

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	VOLATILE ORGANICS (ug/L) (Continued)			
36	Methyl Methanesulfonate*	ND	ND	ND
37	Methacrylonitrile	10000	10000	100
38	Methylene Chloride	500	500	5
39	Pyridine	40000	40000	400
40	1,1,1,2-Tetrachloroethane	500	500	5
41	1,1,2,2-Tetrachloroethane	500	500	5
42	Tetrachloroethene	500	500	5
43	Toluene	500	500	5
44	Tribromomethane	500	500	5
45	1,1,1-Trichloroethane	500	500	5
46	1,1,2-Trichloroethane	500	500	5
47	Trichloroethene	500	500	5
48	Trichloromonofluoromethane	500	500	5
49	1,2,3-Trichloropropane	500	500	5
50	Vinyl Chloride	1000	1000	10
	SEMI-VOLATILE ORGANICS(ug/L)			
51	Acenaphthalene	1500000	150000	30
52	Acenaphthene	1500000	150000	30
53	Acetophenone	3000000	300000	60
54	2-Acetylaminofluorene	3000000	300000	60
55	4-Aminobiphenyl	3000000	300000	60
56	Aniline	1500000	150000	30
57	Anthracene	1500000	150000	30
58	Aramite	NA	NA	NA
59	Benzo(a)anthracene	1500000	150000	30
60	Benzenethiol	ND	ND	ND
61	Benzidine	7500000	750000	150
62	Benzo(a)pyrene	1500000	150000	30
63	Benzo(b)fluoranthene	1500000	150000	30

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 1

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L)(Continued)			
64	Benzo(g,h,i) perylene	1500000	150000	30
65	Benzo(k)fluoranthene	1500000	150000	30
66	p-Benzoquinone	ND	ND	ND
67	Bis(2-Chloroethoxy) methane	1500000	150000	30
68	Bis(2-Chloroethyl) Ether	1500000	150000	30
69	Bis(2-chloroisopropyl) ether	1500000	150000	30
70	Bis(2-ethylhexyl) phthalate	1500000	150000	30
71	4-Bromophenyl phenyl ether	1500000	150000	30
72	Butyl benzyl phthalate	1500000	150000	30
73	2-Sec-Butyl-4,6-Dinitrophenol	7500000	750000	150
74	p-Chloroaniline	1500000	150000	30
75	Chlorobenzilate	NA	NA	NA
76	p-Chloro-m-cresol	1500000	150000	30
77	2-Chloronaphthalene	1500000	150000	30
78	2-Chlorophenol	1500000	150000	30
79	3-Chloropropionitrile	NA	NA	NA
80	Chrysene	1500000	150000	30
81	Ortho-cresol	1500000	150000	30
82	para-cresol	1500000	150000	30
83	Dibenz(a,h)anthracene	1500000	150000	30
84	Dibenzo(a,e,) Pyrene	NA	NA	NA
85	Dibenzo(a,i) Pyrene	NA	NA	NA
86	1,3-Dichlorobenzene	1500000	150000	30
87	1,2-Dichlorobenzene	1500000	150000	30
88	1,4-Dichlorobenzene	1500000	150000	30
89	3,3'Dichlorobenzidine	3000000	300000	60
90	2,4-Dichlorophenol	1500000	150000	30
91	2,6-Dichlorophenol	ND	ND	ND
92	Diethyl phthalate	1500000	150000	30
93	3,3'-Dimethoxybenzidine	1500000	150000	30
94	p-Dimethylaminoazobenzene	3000000	300000	60
95	3,3'-Dimethylbenzidine	ND	ND	ND
96	2,4-Dimethylphenol	1500000	150000	30

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 1

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L)(Continued)			
97	Dimethyl Phthalate	1500000	150000	30
98	Di-n-butyl phthalate	1500000	150000	30
99	1,4-Dinitrobenzene	7500000	750000	150
100	4,6-dinitro-o-cresol	7500000	750000	150
101	2,4-Dinitrophenol	7500000	750000	150
102	2,4-Dinitrotoluene	1500000	150000	30
103	2,6-Dinitrotoluene	1500000	150000	30
104	Di-n-octyl phthalate	1500000	150000	30
105	Di-n-propylnitrosoamine	1500000	150000	30
106	Diphenylamine (1)	3000000	300000	60
107	1,2,-Diphenylhydrazine	7500000	750000	150
108	Fluoranthene	1500000	150000	30
109	Fluorene	1500000	150000	30
110	Hexachlorobenzene	1500000	150000	30
111	Hexachlorobutadiene	1500000	150000	30
112	Hexachlorocyclopentadiene	1500000	150000	30
113	Hexachloroethane	1500000	150000	30
114	Hexachlorophene	NA	NA	NA
115	Hexachloropropene	ND	ND	ND
116	Indeno(1,2,3,-cd) Pyrene	1500000	150000	30
117	Isosafrole	3000000	300000	60
118	Methapyrilene	NA	NA	NA
119	3-Methylcholanthrene	3000000	300000	60
120	4,4'-Methylene-bis-(2-chloroaniline)	3000000	300000	60
121	Naphthalene	1500000	150000	30
122	1,4-Naphthoquinone	NA	NA	NA
123	1-Naphthylamine	7500000	750000	150
124	2-Naphthylamine	7500000	750000	150
125	p-Nitroaniline	7500000	750000	150
126	Nitrobenzene	1500000	150000	30
127	4-Nitrophenol	7500000	750000	150
128	N-Nitrosodi-n-butylamine	ND	ND	ND

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 1

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L)(Continued)			
129	N-Nitrosodiethylamine	ND	ND	ND
130	N-Nitrosodimethylamine	1500000	150000	30
131	N-Nitrosomethylethylamine	1500000	150000	30
132	N-Nitrosomorpholine	3000000	300000	60
133	1-Nitrosopiperidine	1500000	150000	30
134	N-Nitrosopyrrolidine	7500000	750000	150
135	5-Nitro-o-toluidine	3000000	300000	60
136	Pentachlorobenzene	ND	ND	ND
137	Pentachloroethane	NA	NA	NA
138	Pentachloronitrobenzene	15000000	1500000	300
139	Pentachlorophenol	7500000	750000	150
140	Phenacetin	3000000	300000	60
141	Phenanthrene	1500000	150000	30
142	Phenol	1500000	150000	30
143	2-Picoline	1500000	150000	30
144	Pronamide	ND	ND	ND
145	Pyrene	1500000	150000	30
146	Resorcinol	NA	NA	NA
147	Safrole	7500000	750000	150
148	1,2,4,5-Tetrachlorobenzene	3000000	300000	60
149	2,3,4,6-Tetrachlorophenol	ND	ND	ND
150	1,2,4-Trichlorobenzene	1500000	150000	30
151	2,4,5-Trichlorophenol	7500000	750000	150
152	2,4,6-Trichlorophenol	1500000	150000	30
153	Tris(2,3-dibromopropyl) phosphate	ND	ND	ND
**	Benzoic Acid	7500000	750000	150
**	Benzyl Alcohol	1500000	150000	30
**	1,2-Diaminobenzene	ND	ND	ND
**	1,3-Diaminobenzene	ND	ND	ND
**	1,4-Diaminobenzene	ND	ND	ND
**	Diphenylnitrosamine	1500000	150000	30
**	2-Nitroaniline	7500000	750000	150

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 1

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L)(Continued)			
**	3-Nitroaniline	7500000	750000	150
**	2-Nitrophenol	1500000	150000	30
	METALS (ug/L)			
154	Antimony	32.0	32.0	32.0
155	Arsenic	10.0	10.0	10.0
156	Barium	1.0	1.0	1.0
157	Beryllium	1.0	1.0	1.0
158	Cadmium	4.0	4.0	4.0
159	Chromium	7.0	7.0	7.0
160	Copper	6.0	6.0	6.0
161	Lead	5.0	50.0	500.0
162	Mercury	20.0	20.0	20.0
163	Nickel	11.0	11.0	11.0
164	Selenium	5.0	500.0	50.0
165	Silver	6.0	6.0	6.0
166	Thallium	10.0	10.0	1000.0
167	Vanadium	6.0	6.0	6.0
168	Zinc	2.0	2.0	2.0

ND - Constituent was not Detected, however, a matrix detection limit has not been determined.

NA - The standard is not available;compound was searched using an NBS library of 42,000 compounds.

* - This constituent was analyzed as a semivolatile by Method 8270. The Generic Quality Assurance Project Plan for Land Disposal Restrictions Program("BDAT"),EPA/530-SW-87-011,March 1987,lists this compound as a Volatile ,however,it may be analyzed as either a volatile or semivolatile organic

** - This constituent is not on the list of constituents in the Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-011,March 1987. It is a ground-water monitoring constituent as listed in Appendix IX, Page 26639, of the Fedral Register,Vol. 51, No.142.

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 2

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	VOLATILE ORGANICS (ug/L)			
1	Acetonitrile	10000	10000	100
2	Acrolein	10000	10000	100
3	Acrylonitrile	10000	10000	100
4	Benzene	500	500	5
5	Bromodichloromethane	500	500	5
6	Bromomethane	1000	1000	10
7	Carbon Tetrachloride	500	500	5
8	Carbon Disulfide	500	500	5
9	Chlorobenzene	500	500	5
10	2-Chloro-1,3-Butadiene	10000	10000	100
11	Chlorodibromomethane	500	500	5
12	Chloroethane	1000	1000	10
13	2-Chloroethylvinylether	1000	1000	10
14	Chloroform	500	500	5
15	Chloromethane	1000	1000	10
16	3-Chloropropene	10000	10000	100
17	1,2-Dibromo-3-Chloropropane	1000	1000	10
18	1,2-Dibromoethane	500	500	5
19	Dibromomethane	500	500	5
20	Trans-1,4-Dichloro-2-Butene	10000	10000	100
21	Dichlorodifluoromethane	1000	1000	10
22	1,1-Dichloroethane	500	500	5
23	1,2-Dichloroethane	500	500	5
24	1,1-Dichloroethene	500	500	5
25	Trans-1,2-Dichloroethene	500	500	5
26	1,2-Dichloropropane	500	500	5
27	Trans-1,3-Dichloropropene	500	500	5
28	cis-1,3,Dichloropropene	500	500	5
29	1,4-Dioxane	20000	20000	200
30	Ethyl Cyanide	10000	10000	100
31	Ethyl Methacrylate	10000	10000	100
32	Iodomethane	5000	5000	50
33	Isobutyl Alcohol	20000	20000	200
34	Methyl ethyl ketone	10000	10000	100
35	Methyl Methacrylate	10000	10000	100

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 2

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	VOLATILE ORGANICS (ug/L)			
36	Methyl Methanesulfonate*	ND	ND	ND
37	Methacrylonitrile	10000	10000	100
38	Methylene Chloride	500	500	5
39	Pyridine	40000	40000	400
40	1,1,1,2-Tetrachloroethane	500	500	5
41	1,1,2,2-Tetrachloroethane	500	500	5
42	Tetrachloroethene	500	500	5
43	Toluene	500	500	5
44	Tribromomethane	500	500	5
45	1,1,1-Trichloroethane	500	500	5
46	1,1,2-Trichloroethane	500	500	5
47	Trichloroethene	500	500	5
48	Trichloromonofluoromethane	500	500	5
49	1,2,3-Trichloropropane	500	500	5
50	Vinyl Chloride	1000	1000	10
	SEMI-VOLATILE ORGANICS(ug/L)			
51	Acenaphthalene	1500000	150000	30
52	Acenaphthene	1500000	150000	30
53	Acetophenone	3000000	300000	60
54	2-Acetylaminofluorene	3000000	300000	60
55	4-Aminobiphenyl	3000000	300000	60
56	Aniline	1500000	150000	30
57	Anthracene	1500000	150000	30
58	Aramite	NA	NA	NA
59	Benzo(a)anthracene	1500000	150000	30
60	Benzenethiol	ND	ND	ND
61	Benzidine	7500000	750000	150
62	Benzo(a)pyrene	1500000	150000	30
63	Benzo(b)fluoranthene	1500000	150000	30

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 2

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L)(Continued)			
64	Benzo(g,h,i) perylene	1500000	150000	30
65	Benzo(k)fluoranthene	1500000	150000	30
66	p-Benzoquinone	ND	ND	ND
67	Bis(2-Chloroethoxy) methane	1500000	150000	30
68	Bis(2-Chloroethyl) Ether	1500000	150000	30
69	Bis(2-chloroisopropyl) ether	1500000	150000	30
70	Bis(2-ethylhexyl) phthalate	1500000	150000	30
71	4-Bromophenyl phenyl ether	1500000	150000	30
72	Butyl benzyl phthalate	1500000	150000	30
73	2-Sec-Butyl-4,6-Dinitrophenol	7500000	750000	150
74	p-Chloroaniline	1500000	150000	30
75	Chlorobenzilate	NA	NA	NA
76	p-Chloro-m-cresol	1500000	150000	30
77	2-Chloronaphthalene	1500000	150000	30
78	2-Chlorophenol	1500000	150000	30
79	3-Chloropropionitrile	NA	NA	NA
80	Chrysene	1500000	150000	30
81	Ortho-cresol	1500000	150000	30
82	para-cresol	1500000	150000	30
83	Dibenz(a,h)anthracene	1500000	150000	30
84	Dibenzo(a,e,) Pyrene	NA	NA	NA
85	Dibenzo(a,i) Pyrene	NA	NA	NA
86	1,3-Dichlorobenzene	1500000	150000	30
87	1,2-Dichlorobenzene	1500000	150000	30
88	1,4-Dichlorobenzene	1500000	150000	30
89	3,3'Dichlorobenzidine	3000000	300000	60
90	2,4-Dichlorophenol	1500000	150000	30
91	2,6-Dichlorophenol	ND	ND	ND
92	Diethyl phthalate	1500000	150000	30
93	3,3'-Dimethoxybenzidine	1500000	150000	30
94	p-Dimethylaminoazobenzene	3000000	300000	60
95	3,3'-Dimethylbenzidine	ND	ND	ND
96	2,4-Dimethylphenol	1500000	150000	30

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 2

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L)(Continued)			
97	Dimethyl Phthalate	1500000	150000	30
98	Di-n-butyl phthalate	1500000	150000	30
99	1,4-Dinitrobenzene	7500000	750000	150
100	4,6-dinitro-o-cresol	7500000	750000	150
101	2,4-Dinitrophenol	7500000	750000	150
102	2,4-Dinitrotoluene	1500000	150000	30
103	2,6-Dinitrotoluene	1500000	150000	30
104	Di-n-octyl phthalate	1500000	150000	30
105	Di-n-propylnitrosoamine	1500000	150000	30
106	Diphenylamine (1)	3000000	300000	60
107	1,2,-Diphenylhydrazine	7500000	750000	150
108	Fluoranthene	1500000	150000	30
109	Fluorene	1500000	150000	30
110	Hexachlorobenzene	1500000	150000	30
111	Hexachlorobutadiene	1500000	150000	30
112	Hexachlorocyclopentadiene	1500000	150000	30
113	Hexachloroethane	1500000	150000	30
114	Hexachlorophene	NA	NA	NA
115	Hexachloropropene	ND	ND	ND
116	Indeno(1,2,3,-cd) Pyrene	1500000	150000	30
117	Isosafrole	3000000	300000	60
118	Methapyrilene	NA	NA	NA
119	3-Methylcholanthrene	3000000	300000	60
120	4,4'-Methylene-bis-(2-chloroaniline)	3000000	300000	60
121	Naphthalene	1500000	150000	30
122	1,4-Naphthoquinone	NA	NA	NA
123	1-Naphthylamine	7500000	750000	150
124	2-Naphthylamine	7500000	750000	150
125	p-Nitroaniline	7500000	750000	150
126	Nitrobenzene	1500000	150000	30
127	4-Nitrophenol	7500000	750000	150
128	N-Nitrosodi-n-butylamine	ND	ND	ND

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 2

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L)(Continued)			
129	N-Nitrosodiethylamine	ND	ND	ND
130	N-Nitrosodimethylamine	1500000	150000	30
131	N-Nitrosomethylethylamine	1500000	150000	30
132	N-Nitrosomorpholine	3000000	300000	60
133	1-Nitrosopiperidine	1500000	150000	30
134	N-Nitrosopyrrolidine	7500000	750000	150
135	5-Nitro-o-toluidine	3000000	300000	60
136	Pentachlorobenzene	ND	ND	ND
137	Pentachloroethane	NA	NA	NA
138	Pentachloronitrobenzene	15000000	1500000	300
139	Pentachlorophenol	7500000	750000	150
140	Phenacetin	3000000	300000	60
141	Phenanthrene	1500000	150000	30
142	Phenol	1500000	150000	30
143	2-Picoline	1500000	150000	30
144	Pronamide	ND	ND	ND
145	Pyrene	1500000	150000	30
146	Resorcinol	NA	NA	NA
147	Safrole	7500000	750000	150
148	1,2,4,5-Tetrachlorobenzene	3000000	300000	60
149	2,3,4,6-Tetrachlorophenol	ND	ND	ND
150	1,2,4-Trichlorobenzene	1500000	150000	30
151	2,4,5-Trichlorophenol	7500000	750000	150
152	2,4,6-Trichlorophenol	1500000	150000	30
153	Tris(2,3-dibromopropyl) phosphate	ND	ND	ND
**	Benzoic Acid	7500000	750000	150
**	Benzyl Alcohol	1500000	150000	30
**	1,2-Diaminobenzene	ND	ND	ND
**	1,3-Diaminobenzene	ND	ND	ND
**	1,4-Diaminobenzene	ND	ND	ND
**	Diphenylnitrosamine	1500000	150000	30
**	2-Nitroaniline	7500000	750000	150

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 2

		BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
		SEMI-VOLATILE ORGANICS(ug/L)(Continued)			
**		3-Nitroaniline	7500000	750000	150
**		2-Nitrophenol	1500000	150000	30
		METALS (ug/L)			
	154	Antimony	32.0	32.0	32.0
	155	Arsenic	10.0	100.0	100.0
	156	Barium	1.0	1.0	1.0
	157	Beryllium	1.0	1.0	1.0
	158	Cadmium	4.0	4.0	4.0
	159	Chromium	7.0	7.0	7.0
	160	Copper	6.0	6.0	6.0
	161	Lead	5.0	100.0	50.0
	162	Mercury	20.0	20.0	20.0
	163	Nickel	11.0	11.0	11.0
	164	Selenium	5.0	50.0	50.0
	165	Silver	6.0	6.0	6.0
	166	Thallium	10.0	10.0	100.0
	167	Vanadium	6.0	6.0	6.0
	168	Zinc	2.0	2.0	2.0

ND - Constituent was not Detected, however, a matrix detection limit has not been determined.

NA - The standard is not available;compound was searched using an NBS library of 42,000 compounds.

* - This constituent was analyzed as a semivolatile by Method 8270. The Generic Quality Assurance Project Plan for Land Disposal Restrictions Program("BDAT"),EPA/530-SW-87-011,March 1987,lists this compound as a Volatile ,however,it may be analyzed as either a volatile or semivolatile organic

** - This constituent is not on the list of constituents in the Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-011,March 1987. It is a ground-water monitoring constituent as listed in Appendix IX, Page 26639, of the Fedral Register,Vol. 51, No.142.

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 3

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	VOLATILE ORGANICS (ug/L)			
1	Acetonitrile	50000	20000	100
2	Acrolein	50000	20000	100
3	Acrylonitrile	50000	20000	100
4	Benzene	2500	1000	5
5	Bromodichloromethane	2500	1000	5
6	Bromomethane	5000	2000	10
7	Carbon Tetrachloride	2500	1000	5
8	Carbon Disulfide	2500	1000	5
9	Chlorobenzene	2500	1000	5
10	2-Chloro-1,3-Butadiene	50000	20000	100
11	Chlorodibromomethane	2500	1000	5
12	Chloroethane	5000	2000	10
13	2-Chloroethylvinylether	5000	2000	10
14	Chloroform	2500	1000	5
15	Chloromethane	5000	2000	10
16	3-Chloropropene	50000	20000	100
17	1,2-Dibromo-3-Chloropropane	5000	2000	10
18	1,2-Dibromoethane	2500	1000	5
19	Dibromomethane	2500	1000	5
20	Trans-1,4-Dichloro-2-Butene	50000	20000	100
21	Dichlorodifluoromethane	5000	2000	10
22	1,1-Dichloroethane	2500	1000	5
23	1,2-Dichloroethane	2500	1000	5
24	1,1-Dichloroethene	2500	1000	5
25	Trans-1,2-Dichloroethene	2500	1000	5
26	1,2-Dichloropropane	2500	1000	5
27	Trans-1,3-Dichloropropene	2500	1000	5
28	cis-1,3,Dichloropropene	2500	1000	5
29	1,4-Dioxane	100000	40000	200
30	Ethyl Cyanide	50000	20000	100
31	Ethyl Methacrylate	50000	20000	100
32	Iodomethane	25000	10000	50
33	Isobutyl Alcohol	100000	40000	200
34	Methyl ethyl ketone	50000	20000	100
35	Methyl Methacrylate	50000	20000	100

(Continued)

DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 3

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	VOLATILE ORGANICS(ug/L) (Continued)			
36	Methyl Methanesulfonate*	ND	ND	ND
37	Methacrylonitrile	50000	20000	100
38	Methylene Chloride	2500	1000	5
39	Pyridine	200000	80000	400
40	1,1,1,2-Tetrachloroethane	2500	1000	5
41	1,1,2,2-Tetrachloroethane	2500	1000	5
42	Tetrachloroethene	2500	1000	5
43	Toluene	2500	1000	5
44	Tribromomethane	2500	1000	5
45	1,1,1-Trichloroethane	2500	1000	5
46	1,1,2-Trichloroethane	2500	1000	5
47	Trichloroethene	2500	1000	5
48	Trichloromonofluoromethane	2500	1000	5
49	1,2,3-Trichloropropane	2500	1000	5
50	Vinyl Chloride	5000	2000	10
	SEMI-VOLATILE ORGANICS(ug/L)			
51	Acenaphthalene	3000000	150000	150
52	Acenaphthene	3000000	150000	150
53	Acetophenone	6000000	300000	300
54	2-Acetylaminofluorene	6000000	300000	300
55	4-Aminobiphenyl	6000000	300000	300
56	Aniline	3000000	150000	150
57	Anthracene	3000000	150000	150
58	Aramite	NA	NA	NA
59	Benzo(a)anthracene	3000000	150000	150
60	Benzenethiol	ND	ND	ND
61	Benzidine	15000000	750000	750
62	Benzo(a)pyrene	3000000	150000	150
63	Benzo(b)fluoranthene	3000000	150000	150

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 3

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L)(Continued)			
64	Benzo(g,h,i) perylene	3000000	150000	150
65	Benzo(k)fluoranthene	3000000	150000	150
66	p-Benzoquinone	ND	ND	ND
67	Bis(2-Chloroethoxy) methane	3000000	150000	150
68	Bis(2-Chloroethyl) Ether	3000000	150000	150
69	Bis(2-chloroisopropyl) ether	3000000	150000	150
70	Bis(2-ethylhexyl) phthalate	3000000	150000	150
71	4-Bromophenyl phenyl ether	3000000	150000	150
72	Butyl benzyl phthalate	3000000	150000	150
73	2-Sec-Butyl-4,6-Dinitrophenol	15000000	750000	750
74	p-Chloroaniline	3000000	150000	150
75	Chlorobenzilate	NA	NA	NA
76	p-Chloro-m-cresol	3000000	150000	150
77	2-Chloronaphthalene	3000000	150000	150
78	2-Chlorophenol	3000000	150000	150
79	3-Chloropropionitrile	NA	NA	NA
80	Chrysene	3000000	150000	150
81	Ortho-cresol	3000000	150000	150
82	para-cresol	3000000	150000	150
83	Dibenz(a,h)anthracene	3000000	150000	150
84	Dibenzo(a,e,) Pyrene	NA	NA	NA
85	Dibenzo(a,i) Pyrene	NA	NA	ND
86	1,3-Dichlorobenzene	3000000	150000	150
87	1,2-Dichlorobenzene	3000000	150000	150
88	1,4-Dichlorobenzene	3000000	150000	150
89	3,3'Dichlorobenzidine	6000000	300000	300
90	2,4-Dichlorophenol	3000000	150000	150
91	2,6-Dichlorophenol	ND	ND	ND
92	Diethyl phthalate	3000000	150000	150
93	3,3'-Dimethoxybenzidine	3000000	150000	150
94	p-Dimethylaminoazobenzene	6000000	300000	300
95	3,3'-Dimethylbenzidine	ND	ND	ND
96	2,4-Dimethylphenol	3000000	150000	150

(Continued)

APPENDIX C

DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 3

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L)(Continued)			
97	Dimethyl Phthalate	3000000	150000	150
98	Di-n-butyl phthalate	3000000	150000	150
99	1,4-Dinitrobenzene	15000000	750000	750
100	4,6-dinitro-o-cresol	15000000	750000	760
101	2,4-Dinitrophenol	15000000	750000	760
102	2,4-Dinitrotoluene	3000000	150000	150
103	2,6-Dinitrotoluene	3000000	150000	150
104	Di-n-octyl phthalate	3000000	150000	150
105	Di-n-propylnitrosoamine	3000000	150000	150
106	Diphenylamine (1)	6000000	300000	300
107	1,2,-Diphenylhydrazine	15000000	750000	750
108	Fluoranthene	3000000	150000	150
109	Fluorene	3000000	150000	150
110	Hexachlorobenzene	3000000	150000	150
111	Hexachlorobutadiene	3000000	150000	150
112	Hexachlorocyclopentadiene	3000000	150000	150
113	Hexachloroethane	3000000	150000	150
114	Hexachlorophene	NA	NA	NA
115	Hexachloropropene	ND	ND	ND
116	Indeno(1,2,3,-cd) Pyrene	3000000	150000	150
117	Isosafrole	6000000	300000	300
118	Methapyrilene	NA	NA	NA
119	3-Methylcholanthrene	6000000	300000	300
120	4,4'-Methylene-bis-(2-chloroaniline)	6000000	300000	300
121	Naphthalene	3000000	150000	150
122	1,4-Naphthoquinone	NA	NA	NA
123	1-Naphthylamine	15000000	750000	750
124	2-Naphthylamine	15000000	750000	750
125	p-Nitroaniline	15000000	750000	760
126	Nitrobenzene	3000000	150000	150
127	4-Nitrophenol	15000000	750000	760
128	N-Nitrosodi-n-butylamine	ND	ND	ND

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 3

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L)(Continued)			
129	N-Nitrosodiethylamine	ND	ND	ND
130	N-Nitrosodimethylamine	3000000	150000	150
131	N-Nitrosomethylethylamine	3000000	150000	150
132	N-Nitrosomorpholine	6000000	300000	300
133	1-Nitrosopiperidine	3000000	150000	150
134	N-Nitrosopyrrolidine	15000000	750000	750
135	5-Nitro-o-toluidine	6000000	300000	300
136	Pentachlorobenzene	ND	ND	ND
137	Pentachloroethane	NA	NA	NA
138	Pentachloronitrobenzene	30000000	1500000	1500
139	Pentachlorophenol	15000000	750000	760
140	Phenacetin	6000000	300000	300
141	Phenanthrene	3000000	150000	150
142	Phenol	3000000	150000	150
143	2-Picoline	3000000	150000	150
144	Pronamide	ND	ND	ND
145	Pyrene	3000000	150000	150
146	Resorcinol	NA	NA	NA
147	Safrole	15000000	750000	750
148	1,2,4,5-Tetrachlorobenzene	6000000	300000	300
149	2,3,4,6-Tetrachlorophenol	ND	ND	ND
150	1,2,4-Trichlorobenzene	3000000	150000	150
151	2,4,5-Trichlorophenol	15000000	750000	760
152	2,4,6-Trichlorophenol	3000000	150000	150
153	Tris(2,3-dibromopropyl) phosphate	ND	ND	ND
**	Benzoic Acid	15000000	750000	760
**	Benzyl Alcohol	3000000	150000	150
**	1,2-Diaminobenzene	ND	ND	ND
**	1,3-Diaminobenzene	ND	ND	ND
**	1,4-Diaminobenzene	ND	ND	ND
**	Diphenylnitrosoamine	15000000	750000	760
**	2-Nitroaniline	15000000	750000	760
**	3-Nitroaniline	15000000	750000	760
**	2-Nitrophenol	3000000	150000	150

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 3

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	METALS (ug/L)			
154	Antimony	32.0	32.0	32.0
155	Arsenic	10.0	10.0	10.0
156	Barium	1.0	1.0	1.0
157	Beryllium	1.0	1.0	1.0
158	Cadmium	4.0	4.0	4.0
159	Chromium	7.0	7.0	7.0
160	Copper	6.0	6.0	6.0
161	Lead	5.0	5.0	5.0
162	Mercury	20.0	20.0	20.0
163	Nickel	11.0	11.0	11.0
164	Selenium	5.0	50.0	50.0
165	Silver	6.0	6.0	6.0
166	Thallium	10.0	10.0	10.0
167	Vanadium	6.0	6.0	6.0
168	Zinc	2.0	2.0	2.0

ND - Constituent was not Detected, however, a matrix detection limit has not been determined.

NA - The standard is not available;compound was searched using an NBS library of 42,000 compounds.

* - This constituent was analyzed as a semivolatile by Method 8270. The Generic Quality Assurance Project Plan for Land Disposal Restrictions Program("BDAT"),EPA/530-SW-87-011,March 1987,lists this compound as a Volatile ,however,it may be analyzed as either a volatile or semivolatile organic

** - This constituent is not on the list of constituents in the Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-011,March 1987. It is a ground-water monitoring constituent as listed in Appendix IX, Page 26639, of the Fedral Register,Vol. 51, No.142.

APPENDIX C

DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 4

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	VOLATILE ORGANICS(ug/L)			
1	Acetonitrile	50000	10000	100
2	Acrolein	50000	10000	100
3	Acrylonitrile	50000	10000	100
4	Benzene	2500	500	5
5	Bromodichloromethane	2500	500	5
6	Bromomethane	5000	1000	10
7	Carbon Tetrachloride	2500	500	5
8	Carbon Disulfide	2500	500	5
9	Chlorobenzene	2500	500	5
10	2-Chloro-1,3-Butadiene	50000	10000	100
11	Chlorodibromomethane	2500	500	5
12	Chloroethane	5000	1000	10
13	2-Chloroethylvinylether	5000	1000	10
14	Chloroform	2500	500	5
15	Chloromethane	5000	1000	10
16	3-Chloropropene	50000	10000	100
17	1,2-Dibromo-3-Chloropropane	5000	1000	10
18	1,2-Dibromoethane	2500	500	5
19	Dibromomethane	2500	500	5
20	Trans-1,4-Dichloro-2-Butene	50000	10000	100
21	Dichlorodifluoromethane	5000	1000	10
22	1,1-Dichloroethane	2500	500	5
23	1,2-Dichloroethane	2500	500	5
24	1,1-Dichloroethene	2500	500	5
25	Trans-1,2-Dichloroethene	2500	500	5
26	1,2-Dichloropropane	2500	500	5
27	Trans-1,3-Dichloropropene	2500	500	5
28	cis-1,3,Dichloropropene	2500	500	5
29	1,4-Dioxane	100000	20000	200
30	Ethyl Cyanide	50000	10000	100
31	Ethyl Methacrylate	50000	10000	100
32	Iodomethane	25000	5000	50
33	Isobutyl Alcohol	100000	20000	200
34	Methyl ethyl ketone	50000	10000	100
35	Methyl Methacrylate	50000	10000	100

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 4

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	VOLATILE ORGANICS(ug/L) (Continued)			
36	Methyl Methanesulfonate*	ND	ND	ND
37	Methacrylonitrile	50000	10000	100
38	Methylene Chloride	2500	500	5
39	Pyridine	200000	40000	400
40	1,1,1,2-Tetrachloroethane	2500	500	5
41	1,1,2,2-Tetrachloroethane	2500	500	5
42	Tetrachloroethene	2500	500	5
43	Toluene	2500	500	5
44	Tribromomethane	2500	500	5
45	1,1,1-Trichloroethane	2500	500	5
46	1,1,2-Trichloroethane	2500	500	5
47	Trichloroethene	2500	500	5
48	Trichloromonofluoromethane	2500	500	5
49	1,2,3-Trichloropropane	2500	500	5
50	Vinyl Chloride	5000	1000	10
	SEMI-VOLATILE ORGANICS(ug/L)			
51	Acenaphthylene	3000000	300000	30
52	Acenaphthene	3000000	300000	30
53	Acetophenone	6000000	600000	60
54	2-Acetylaminofluorene	6000000	600000	60
55	4-Aminobiphenyl	6000000	600000	60
56	Aniline	3000000	300000	30
57	Anthracene	3000000	300000	30
58	Aramite	NA	NA	NA
59	Benzo(a)anthracene	3000000	300000	30
60	Benzenethiol	ND	ND	ND
61	Benzidine	15000000	1500000	150
62	Benzo(a) Pyrene	3000000	300000	30
63	Benzo(b)Fluoranthene	3000000	300000	30

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 4

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L) (Continued)			
64	Benzo(g,h,i) perylene	3000000	300000	30
65	Benzo(k)fluoranthene	3000000	300000	30
66	p-Benzoquinone	ND	ND	ND
67	Bis(2-Chloroethoxy) methane	3000000	300000	30
68	Bis(2-Chloroethyl) Ether	3000000	300000	30
69	Bis(2-chloroisopropyl) ether	3000000	300000	30
70	Bis(2-ethylhexyl) phthalate	3000000	300000	30
71	4-Bromophenyl phenyl ether	3000000	300000	30
72	Butyl benzyl phthalate	3000000	300000	30
73	2-Sec-Butyl-4,6-Dinitrophenol	15000000	1500000	150
74	p-Chloroaniline	3000000	300000	30
75	Chlorobenzilate	NA	NA	NA
76	p-Chloro-m-cresol	3000000	300000	30
77	2-Chloronaphthalene	3000000	300000	30
78	2-Chlorophenol	3000000	300000	30
79	3-Chloropropionitrile	NA	NA	NA
80	Chrysene	3000000	300000	30
81	Ortho-cresol	3000000	300000	30
82	para-cresol	3000000	300000	30
83	Dibenz(a,h)anthracene	3000000	300000	30
84	Dibenzo(a,e,) Pyrene	NA	NA	NA
85	Dibenzo(a,i) Pyrene	NA	NA	NA
86	1,3-Dichlorobenzene	3000000	300000	30
87	1,2-Dichlorobenzene	3000000	300000	30
88	1,4-Dichlorobenzene	3000000	300000	30
89	3,3'Dichlorobenzidine	6000000	600000	60
90	2,4-Dichlorophenol	3000000	300000	30
91	2,6-Dichlorophenol	ND	ND	ND
92	Diethyl phthalate	3000000	300000	30
93	3,3'-Dimethoxybenzidine	3000000	300000	30
94	p-Dimethylaminoazobenzene	6000000	600000	60
95	3,3'-Dimethylbenzidine	ND	ND	ND
96	2,4-Dimethylphenol	3000000	300000	30

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 4

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L) (Continued)			
97	Dimethyl Phthalate	3000000	300000	30
98	Di-n-butyl phthalate	3000000	300000	30
99	1,4-Dinitrobenzene	15000000	1500000	150
100	4,6-dinitro-o-cresol	15000000	1500000	150
101	2,4-Dinitrophenol	15000000	1500000	150
102	2,4-Dinitrotoluene	3000000	300000	30
103	2,6-Dinitrotoluene	3000000	300000	30
104	Di-n-octyl phthalate	3000000	300000	30
105	Di-n-propylnitrosoamine	3000000	300000	30
106	Diphenylamine (1)	6000000	600000	60
107	1,2,-Diphenylhydrazine	15000000	1500000	150
108	Fluoranthene	3000000	300000	30
109	Fluorene	3000000	300000	30
110	Hexachlorobenzene	3000000	300000	30
111	Hexachlorobutadiene	3000000	300000	30
112	Hexachlorocyclopentadiene	3000000	300000	30
113	Hexachloroethane	3000000	300000	30
114	Hexachlorophene	NA	NA	NA
115	Hexachloropropene	ND	ND	ND
116	Indeno(1,2,3,-cd) Pyrene	3000000	300000	30
117	Isosafrole	6000000	600000	60
118	Methapyrilene	NA	NA	NA
119	3-Methylcholanthrene	6000000	600000	60
120	4,4'-Methylene-bis-(2-chloroaniline)	6000000	600000	60
121	Naphthalene	3000000	300000	30
122	1,4-Naphthoquinone	NA	NA	NA
123	1-Naphthylamine	15000000	1500000	150
124	2-Naphthylamine	15000000	1500000	150
125	p-Nitroaniline	15000000	1500000	150
126	Nitrobenzene	3000000	300000	30
127	4-Nitrophenol	15000000	1500000	150
128	N-Nitrosodi-n-butylamine	NA	NA	NA

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 4

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L) (Continued)			
129	N-Nitrosodiethylamine	ND	ND	ND
130	N-Nitrosodimethylamine	3000000	300000	30
131	N-Nitrosomethylethylamine	3000000	300000	30
132	N-Nitrosomorpholine	6000000	600000	60
133	1-Nitrosopiperidine	3000000	300000	30
134	N-Nitrosopyrrolidine	15000000	1500000	150
135	5-Nitro-o-toluidine	6000000	600000	60
136	Pentachlorobenzene	ND	ND	ND
137	Pentachloroethane	NA	NA	NA
138	Pentachloronitrobenzene	30000000	3000000	300
139	Pentachlorophenol	15000000	1500000	150
140	Phenacetin	6000000	600000	60
141	Phenanthrene	3000000	300000	30
142	Phenol	3000000	300000	30
143	2-Picoline	3000000	300000	30
144	Pronamide	ND	ND	ND
145	Pyrene	3000000	300000	30
146	Resorcinol	NA	NA	NA
147	Safrole	15000000	1500000	150
148	1,2,4,5-Tetrachlorobenzene	6000000	600000	60
149	2,3,4,6-Tetrachlorophenol	ND	ND	ND
150	1,2,4-Trichlorobenzene	3000000	300000	30
151	2,4,5-Trichlorophenol	15000000	1500000	150
152	2,4,6-Trichlorophenol	3000000	300000	30
153	Tris(2,3-dibromopropyl) phosphate	ND	ND	ND
**	Benzoic Acid	15000000	1500000	150
**	1,2-Diaminobenzene	ND	ND	ND
**	1,3-Diaminobenzene	ND	ND	ND
**	1,4-Diaminobenzene	ND	ND	ND
**	2-Nitroaniline	15000000	1500000	150

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 4

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L) (Continued)			
**	3-Nitroaniline	15000000	1500000	150
**	2-Nitrophenol	3000000	300000	30
	METALS (ug/L)			
154	Antimony	32.0	32.0	32.0
155	Arsenic	10.0	10.0	500.0
156	Barium	1.0	1.0	1.0
157	Beryllium	1.0	1.0	1.0
158	Cadmium	4.0	4.0	4.0
159	Chromium	7.0	7.0	7.0
160	Copper	6.0	6.0	6.0
161	Lead	5.0	5.0	5.0
162	Mercury	20.0	20.0	20.0
163	Nickel	11.0	11.0	11.0
164	Selenium	5.0	50.0	50.0
165	Silver	6.0	6.0	6.0
166	Thallium	10.0	10.0	10.0
167	Vanadium	6.0	6.0	6.0
168	Zinc	2.0	2.0	2.0

ND - Constituent was not Detected, however, a matrix detection limit has not been determined.

NA - The standard is not available;compound was searched using an NBS library of 42,000 compounds.

* - This constituent was analyzed as a semivolatile by Method 8270. The Generic Quality Assurance Project Plan for Land Disposal Restrictions Program("BDAT"),EPA/530-SW-87 -011,March 1987,lists this compound as a Volatile ,however,it may be analyzed as either a volatile or semivolatile organic

** - This constituent is not on the list of constituents in the Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-011,March 1987. It is a ground-water monitoring constituent as listed in Appendix IX, Page 26639, of the Fedral Register,Vol. 51, No.142.

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 5

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	VOLATILE ORGANICS(ug/L)			
1	Acetonitrile	50000	5000	100
2	Acrolein	50000	5000	100
3	Acrylonitrile	50000	5000	100
4	Benzene	2500	250	5
5	Bromodichloromethane	2500	250	5
6	Bromomethane	5000	500	10
7	Carbon Tetrachloride	2500	250	5
8	Carbon Disulfide	2500	250	5
9	Chlorobenzene	2500	250	5
10	2-Chloro-1,3-Butadiene	50000	5000	100
11	Chlorodibromomethane	2500	250	5
12	Chloroethane	5000	500	10
13	2-Chloroethylvinylether	5000	500	10
14	Chloroform	2500	250	5
15	Chloromethane	5000	500	10
16	3-Chloropropene	50000	5000	100
17	1,2-Dibromo-3-Chloropropane	5000	500	10
18	1,2-Dibromoethane	2500	250	5
19	Dibromomethane	2500	250	5
20	Trans-1,4-Dichloro-2-Butene	50000	5000	100
21	Dichlorodifluoromethane	5000	500	10
22	1,1-Dichloroethane	2500	250	5
23	1,2-Dichloroethane	2500	250	5
24	1,1-Dichloroethene	2500	250	5
25	Trans-1,2-Dichloroethene	2500	250	5
26	1,2-Dichloropropane	2500	250	5
27	Trans-1,3-Dichloropropene	2500	250	5
28	cis-1,3,Dichloropropene	2500	250	5
29	1,4-Dioxane	100000	10000	200
30	Ethyl Cyanide	50000	5000	100
31	Ethyl Methacrylate	50000	5000	100
32	Iodomethane	25000	2500	50
33	Isobutyl Alcohol	100000	10000	200
34	Methyl ethyl ketone	50000	5000	100
35	Methyl Methacrylate	50000	5000	100

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 5

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	VOLATILE ORGANICS(ug/L) (Continued)			
36	Methyl Methanesulfonate*	ND	ND	ND
37	Methacrylonitrile	50000	5000	100
38	Methylene Chloride	2500	250	5
39	Pyridine	200000	20000	400
40	1,1,1,2-Tetrachloroethane	2500	250	5
41	1,1,2,2-Tetrachloroethane	2500	250	5
42	Tetrachloroethene	2500	250	5
43	Toluene	2500	250	5
44	Tribromomethane	2500	250	5
45	1,1,1-Trichloroethane	2500	250	5
46	1,1,2-Trichloroethane	2500	250	5
47	Trichloroethene	2500	250	5
48	Trichloromonofluoromethane	2500	250	5
49	1,2,3-Trichloropropane	2500	250	5
50	Vinyl Chloride	5000	500	10
	SEMI-VOLATILE ORGANICS(ug/L)			
51	Acenaphthalene	3000000	300000	30
52	Acenaphthene	3000000	300000	30
53	Acetophenone	6000000	600000	60
54	2-Acetylaminofluorene	6000000	600000	60
55	4-Aminobiphenyl	6000000	600000	60
56	Aniline	3000000	300000	30
57	Anthracene	3000000	300000	30
58	Aramite	NA	NA	NA
59	Benzo(a)anthracene	3000000	300000	30
60	Benzenethiol	ND	ND	ND
61	Benzidine	15000000	1500000	150
62	Benzo(a)pyrene	3000000	300000	30
63	Benzo(b)fluoranthene	3000000	300000	30

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 5

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L) (Continued)			
64	Benzo(g,h,i) perylene	3000000	300000	30
65	Benzo(k)fluoranthene	3000000	300000	30
66	p-Benzoquinone	ND	ND	ND
67	Bis(2-Chloroethoxy) methane	3000000	300000	30
68	Bis(2-Chloroethyl) Ether	3000000	300000	30
69	Bis(2-chloroisopropyl) ether	3000000	300000	30
70	Bis(2-ethylhexyl) phthalate	3000000	300000	30
71	4-Bromophenyl phenyl ether	3000000	300000	30
72	Butyl benzyl phthalate	3000000	300000	30
73	2-Sec-Butyl-4,6-Dinitrophenol	15000000	1500000	150
74	p-Chloroaniline	3000000	300000	30
75	Chlorobenzilate	NA	NA	NA
76	p-Chloro-m-cresol	3000000	300000	30
77	2-Chloronaphthalene	3000000	300000	30
78	2-Chlorophenol	3000000	300000	30
79	3-Chloropropionitrile	NA	NA	NA
80	Chrysene	3000000	300000	30
81	Ortho-cresol	3000000	300000	30
82	para-cresol	3000000	300000	30
83	Dibenz(a,h)anthracene	3000000	300000	30
84	Dibenzo(a,e,) Pyrene	NA	NA	NA
85	Dibenzo(a,i) Pyrene	NA	NA	NA
86	1,3-Dichlorobenzene	3000000	300000	30
87	1,2-Dichlorobenzene	3000000	300000	30
88	1,4-Dichlorobenzene	3000000	300000	30
89	3,3'Dichlorobenzidine	6000000	600000	60
90	2,4-Dichlorophenol	3000000	300000	30
91	2,6-Dichlorophenol	ND	ND	ND
92	Diethyl phthalate	3000000	300000	30
93	3,3'-Dimethoxybenzidine	3000000	300000	30
94	p-Dimethylaminoazobenzene	6000000	600000	60
95	3,3'-Dimethylbenzidine	ND	ND	ND
96	2,4-Dimethylphenol	3000000	300000	30

(Continued)

DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 5

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L) (Continued)			
97	Dimethyl Phthalate	3000000	300000	30
98	Di-n-butyl phthalate	3000000	300000	30
99	1,4-Dinitrobenzene	15000000	1500000	150
100	4,6-dinitro-o-cresol	15000000	1500000	150
101	2,4-Dinitrophenol	15000000	1500000	150
102	2,4-Dinitrotoluene	3000000	300000	30
103	2,6-Dinitrotoluene	3000000	300000	30
104	Di-n-octyl phthalate	3000000	300000	30
105	Di-n-propylnitrosoamine	3000000	300000	30
106	Diphenylamine (1)	6000000	600000	60
107	1,2,-Diphenylhydrazine	15000000	1500000	150
108	Fluoranthene	3000000	300000	30
109	Fluorene	3000000	300000	30
110	Hexachlorobenzene	3000000	300000	30
111	Hexachlorobutadiene	3000000	300000	30
112	Hexachlorocyclopentadiene	3000000	300000	30
113	Hexachloroethane	3000000	300000	30
114	Hexachlorophene	NA	NA	NA
115	Hexachloropropene	ND	ND	ND
116	Indeno(1,2,3,-cd) Pyrene	3000000	300000	30
117	Isosafrole	6000000	600000	60
118	Methapyrilene	NA	NA	NA
119	3-Methylcholanthrene	6000000	600000	60
120	4,4'-Methylene-bis-(2-chloroaniline)	6000000	600000	60
121	Naphthalene	3000000	300000	30
122	1,4-Naphthoquinone	NA	NA	NA
123	1-Naphthylamine	15000000	1500000	150
124	2-Naphthylamine	15000000	1500000	150
125	p-Nitroaniline	15000000	1500000	150
126	Nitrobenzene	3000000	300000	30
127	4-Nitrophenol	15000000	1500000	150
128	N-Nitrosodi-n-butylamine	ND	ND	ND

(Continued)

APPENDIX C DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 5

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L) (Continued)			
129	N-Nitrosodiethylamine	ND	ND	ND
130	N-Nitrosodimethylamine	3000000	300000	30
131	N-Nitrosomethylethylamine	3000000	300000	30
132	N-Nitrosomorpholine	6000000	600000	60
133	1-Nitrosopiperidine	3000000	300000	30
134	N-Nitrosopyrrolidine	15000000	1500000	150
135	5-Nitro-o-toluidine	3000000	300000	60
136	Pentachlorobenzene	ND	ND	ND
137	Pentachloroethane	NA	NA	NA
138	Pentachloronitrobenzene	30000000	3000000	300
139	Pentachlorophenol	15000000	1500000	150
140	Phenacetin	6000000	600000	60
141	Phenanthrene	3000000	300000	30
142	Phenol	3000000	300000	30
143	2-Picoline	3000000	300000	30
144	Pronamide	ND	ND	ND
145	Pyrene	3000000	300000	30
146	Resorcinol	NA	NA	NA
147	Safrole	15000000	1500000	150
148	1,2,4,5-Tetrachlorobenzene	6000000	600000	60
149	2,3,4,6-Tetrachlorophenol	ND	ND	ND
150	1,2,4-Trichlorobenzene	3000000	300000	30
151	2,4,5-Trichlorophenol	15000000	1500000	150
152	2,4,6-Trichlorophenol	3000000	300000	30
153	Tris(2,3-dibromopropyl) phosphate	ND	ND	ND
**	Benzoic Acid	15000000	1500000	150
**	Benzyl Alcohol	3000000	300000	30
**	1,2-Diaminobenzene	ND	ND	ND
**	1,3-Diaminobenzene	ND	ND	ND
**	1,4-Diaminobenzene	ND	ND	ND
**	Diphenylnitrosoamine	15000000	1500000	150
**	2-Nitroaniline	15000000	1500000	150

(Continued)

APPENDIX C   DETECTION LIMITS FOR CONSTITUENTS IN THE UNTREATED AND TREATED WASTE OF SAMPLE SET 5

	BDAT CONSTITUENT	UNTREATED K103	UNTREATED K104	TREATED K103 & K104
	SEMI-VOLATILE ORGANICS(ug/L) (Continued)			
**	3-Nitroaniline	15000000	1500000	150
**	2-Nitrophenol	3000000	300000	30
	METALS (ug/L)			
154	Antimony	32.0	32.0	32.0
155	Arsenic	500.0	500.0	10.0
156	Barium	1.0	1.0	1.0
157	Beryllium	1.0	1.0	1.0
158	Cadmium	4.0	4.0	4.0
159	Chromium	7.0	7.0	7.0
160	Copper	6.0	6.0	6.0
161	Lead	5.0	50.0	100.0
162	Mercury	20.0	20.0	20.0
163	Nickel	11.0	11.0	11.0
164	Selenium	5.0	50.0	50.0
165	Silver	6.0	6.0	6.0
166	Thallium	10.0	10.0	10.0
167	Vanadium	6.0	6.0	6.0
168	Zinc	2.0	2.0	2.0

ND - Constituent was not Detected, however, a matrix detection limit has not been determined.

NA - The standard is not available;compound was searched using an NBS library of 42,000 compounds.

* - This constituent was analyzed as a semivolatile by Method 8270. The Generic Quality Assurance Project Plan for Land Disposal Restrictions Program("BDAT"),EPA/530-SW-87 -011,March 1987,lists this compound as a Volatile ,however,it may be analyzed as either a volatile or semivolatile organic

** - This constituent is not on the list of constituents in the Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT"), EPA/530-SW-011,March 1987. It is a ground-water monitoring constituent as listed in Appendix IX, Page 26639, of the Fedral Register,Vol. 51, No.142.

APPENDIX D Calculation of Treatment Standards

Constituent: Benzene

Sample Set	Effluent[1] Concentration (mg/l)	Percent[2] Recovery	Accuracy[3] Correction Factor	Corrected[4] Concentration (mg/l)	Log[5] Transform
1	0.042	76	1.32	0.055	-2.900
2	0.005	76	1.32	0.007	-4.962
4	0.019	76	1.32	0.025	-3.689
5	0.011	76	1.32	0.015	-4.200
			x =	0.026	y = -3.938
					s = 0.867

1 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 6-14.
2 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 7-12.
3 - Accuracy Correction Factor = 100 / Percent Recovery.
4 - Corrected Concentration = Effluent Concentration X Accuracy Correction Factor.
5 - Log Transform using the natural logarithm, ln, of the Corrected Concentration.

Treatment Standard = Corrected Effluent Mean X VF

Calculation of Variability Factor (VF):

$C_{99} = \exp(y + 2.33s)$

where

y = the mean of the log transforms
s = the standard deviation of the log transforms.

Therefore, $C_{99} = \exp(-3.938 + 2.33(0.867))$
$= \exp(-1.918)$
$= 0.147$

and $VF = C_{99} / x$

where

x = the mean of the corrected effluent concentrations.

Therefore, $VF = C_{99} / x$
$= 0.147 / 0.026$
$= 5.654$

Treatment Standard = Corrected Effluent Mean X VF
= 0.026 X 5.654
= 0.147 mg/l

APPENDIX D Calculation of Treatment Standards

Constituent: Aniline

Sample Set	Effluent Concentration (mg/l) 1	Percent Recovery 2	Accuracy Correction Factor 3	Corrected Concentration (mg/l) 4	Log Transform 5
1	0.030	91	1.10	0.033	-3.411
2	0.030	91	1.10	0.033	-3.411
4	0.030	91	1.10	0.033	-3.411
5	0.960	91	1.10	1.056	0.054
			x =	0.289	y = -2.545
					s = 1.733

1 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 6-14.

2 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 7-13.

3 - Accuracy Correction Factor = 100 / Percent Recovery.

4 - Corrected Concentration = Effluent Concentration X Accuracy Correction Factor.

5 - Log Transform using the natural logarithm, ln, of the Corrected Concentration.

Treatment Standard = Corrected Effluent Mean X VF

Calculation of Variability Factor (VF):

$C_{99} = \exp(y + 2.33s)$

where

y = the mean of the log transforms

s = the standard deviation of the log transforms.

Therefore, $C_{99} = \exp(-2.545 + 2.33(1.733))$

$= \exp(1.493)$

$= 4.450$

and $VF = C_{99} / x$

where

x = the mean of the corrected effluent concentrations.

Therefore, $VF = C_{99} / x$

$= 4.450 / 0.289$

$= 15.398$

Treatment Standard = Corrected Effluent Mean X VF

= 0.289 X 15.398

= 4.450 mg/l

APPENDIX D Calculation of Treatment Standards

Constituent: 2,4-Dinitrophenol

Sample Set	Effluent Concentration (mg/l) 1	Percent 2* Recovery	Accuracy 3 Correction Factor	Corrected 4 Concentration (mg/l)	Log 5 Transform
1	0.380	80	1.25	0.475	-0.744
2	0.320	80	1.25	0.400	-0.916
4	0.260	80	1.25	0.325	-1.124
5	0.230	80	1.25	0.288	-1.245
			x =	0.372 y =	-1.007
				s =	0.222

1 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 6-14.

2 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 7-13.

* - Average of Percent Recovery for Semivolatiles with greater than or equal to 20% recovery as listed in Table 7-13.

3 - Accuracy Correction Factor = 100 / Percent Recovery.

4 - Corrected Concentration = Effluent Concentration X Accuracy Correction Factor.

5 - Log Transform using the natural logarithm, ln, of the Corrected Concentration.

Treatment Standard = Corrected Effluent Mean X VF

Calculation of Variability Factor (VF):

$C_{99} = \exp(y + 2.33s)$

where

y = the mean of the log transforms

s = the standard deviation of the log transforms.

Therefore, $C_{99} = \exp(-1.007 + 2.33(0.222))$
$= \exp(-0.490)$
$= 0.613$

and $VF = C_{99} / x$

where

x = the mean of the corrected effluent concentrations.

Therefore, $VF = C_{99} / x$
$= 0.613 / 0.372$
$= 1.648$

Treatment Standard = Corrected Effluent Mean X VF
= 0.372 X 1.648
= 0.613 mg/l

APPENDIX D Calculation of Treatment Standards

Constituent: Nitrobenzene

Sample Set	Effluent Concentration (mg/l) 1	Percent Recovery 2	Accuracy Correction Factor 3	Corrected Concentration (mg/l) 4	Log Transform 5
1	0.03	115	0.87	0.026	-3.650
2	0.03	115	0.87	0.026	-3.650
4	0.03	115	0.87	0.026	-3.650
5	0.03	115	0.87	0.026	-3.650
			x =	0.026	y = -3.650
					s = 0.000

1 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 6-14.

2 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 7-13.

3 - Accuracy Correction Factor = 100 / Percent Recovery.

4 - Corrected Concentration = Effluent Concentration X Accuracy Correction Factor.

5 - Log Transform using the natural logarithm, ln, of the Corrected Concentration.

Treatment Standard = Corrected Effluent Mean X VF

Calculation of Variability Factor (VF):

C_{99} = exp (y + 2.33s)

where

y = the mean of the log transforms

s = the standard deviation of the log transforms.

Therefore, C_{99} = exp (-3.650 + 2.33(0))

= exp (-3.650)

= 0.026

and VF = C_{99} / x

where

x = the mean of the corrected effluent concentrations.

Therefore, VF = C_{99} / x

= 0.026 / 0.026

= 1

A variability factor of one was not used in calculating the treatment standards.
The variability factor of 2.80 was substituted for the value 1.

VF = 2.80

Treatment Standard = Corrected Effluent Mean X VF

= 0.026 X 2.80

= 0.073 mg/l

APPENDIX D Calculation of Treatment Standards

Constituent: Phenol

Sample Set	Effluent Concentration (mg/l) 1	Percent Recovery 2	Accuracy Correction Factor 3	Corrected Concentration (mg/l) 4	Log Transform 5
1	0.030	21	4.76	0.143	-1.945
2	0.030	21	4.76	0.143	-1.945
4	0.030	21	4.76	0.143	-1.945
5	0.150	21	4.76	0.714	-0.337
			x =	0.286	y = -1.543
					s = 0.804

1 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 6-14.

2 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 7-13.

3 - Accuracy Correction Factor = 100 / Percent Recovery.

4 - Corrected Concentration = Effluent Concentration X Accuracy Correction Factor.

5 - Log Transform using the natural logarithm, ln, of the Corrected Concentration.

Treatment Standard = Corrected Effluent Mean X VF

Calculation of Variability Factor (VF):

$C_{99} = \exp(y + 2.33s)$

where

y = the mean of the log transforms

s = the standard deviation of the log transforms.

Therefore, $C_{99} = \exp(-1.543 + 2.33(0.804))$

$= \exp(0.330)$

$= 1.391$

and $VF = C_{99} / x$

where

x = the mean of the corrected effluent concentrations.

Therefore, $VF = C_{99} / x$

$= 1.391 / 0.286$

$= 4.864$

Treatment Standard = Corrected Effluent Mean X VF

= 0.286 X 4.864

= 1.391 mg/l

APPENDIX D Calculation of Treatment Standards

Constituent: Total Cyanides

Sample Set	Effluent Concentration (mg/l) [1]	Percent Recovery [2]	Accuracy Correction Factor [3]	Corrected Concentration (mg/l) [4]	Log Transform [5]
1	0.565	72	1.39	0.785	-0.242
2	0.597	72	1.39	0.830	-0.186
4	0.156	72	1.39	0.217	-1.528
5	0.129	72	1.39	0.179	-1.720
			x =	0.503 y =	-0.919
				s =	0.818

1 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 6-14.
2 - Obtained from the Onsite Engineering Report, E. I. du Pont de Nemours, Table 7-14.
3 - Accuracy Correction Factor = 100 / Percent Recovery.
4 - Corrected Concentration = Effluent Concentration X Accuracy Correction Factor.
5 - Log Transform using the natural logarithm, ln, of the Corrected Concentration.

Treatment Standard = Corrected Effluent Mean X VF

Calculation of Variability Factor (VF):

C_{99} = exp (y + 2.33s)
where
y = the mean of the log transforms
s = the standard deviation of the log transforms.

Therefore, C_{99} = exp (-0.919 + 2.33(0.818))
= exp (0.987)
= 2.683

and VF = C_{99} / x
where
x = the mean of the corrected effluent concentrations.

Therefore, VF = C_{99} / x
= 2.683 / 0.503
= 5.334

Treatment Standard = Corrected Effluent Mean X VF
= 0.503 x 5.334
= 2.683 mg/l

APPENDIX E - ANALYTICAL QA/QC

The analytical methods used for analysis of the regulated constituents identified in Section 5 are listed in Table E-1. SW-846 methods (EPA's Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-846, Third Edition, November 1986) are used in most cases for determining total waste concentrations.

Deviations from SW-846 methods required to analyze the sample matrix are listed in Table E-2. These deviations are approved methods for determining constituent concentrations. SW-846 also allows for the use of alternative or equivalent procedures or equipment; these are described in Tabled E-3 through E-5. These alternatives or equivalents included use of alternative sample preparation methods and/or use of different extraction techniques to reduce sample matrix interferences.

The accuracy determination for a constituent is based on the matrix spike recovery values. Table E-6 present the matrix spike recovery values for total waste concentrations of benzene, aniline, nitrobenzene, and phenol for K103/K104 and for total cyanides for K104 for the EPA-collected data. Because 2,4-dinitrophenol matrix spike recoveries were not collected, the average of the percent recoveries equal to or greater than 20 percent for all semivolatiles was used as the percent recovery for 2,4-dinitrophenol.

The accuracy correction factors for the regulated constituents for the treatment residuals are presented in Table E-6. The accuracy correction factors were determined in accordance with the general methodology presented in the Introduction. For example, for benzene, actual spike recovery data were obtained for analysis of liquid matrices and the lowest percent recovery value was used to calculate the accuracy correction factor. An example of the calculation of the corrected concentration value for benzene is shown below.

Analytical value	Average % recovery	Correction factor	Corrected value
0.042 mg/kg	76	$\frac{100}{76} = 1.32$	1.32 x 0.042 = 0.055 mg/kg

Table E-1 Analytical Methods for Regulated Constituents[a]

Regulated Constituent	Analytical Method	Method Number
Volatiles		
Benzene	Purge and Trap	5030
	Gas Chromatography/Mass Spectrometry for Volatile Organics	8240
Semivolatiles		
Aniline	Continuous Liquid/Liquid Extraction	3520
2,4-Dinitrophenol		
Nitrobenzene		
Phenol	Gas Chromatography/Mass Spectrometry Column Technique	8270
Inorganics		
Cyanides	Total and Amenable Cyanides	9012

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[a] - Environmental Protection Agency. 1986. Test Methods for Evaluating Solid Waste. Third Edition. U. S. EPA. Office of Solid Waste and Emergency Response. November 1986.

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Table E-2 Deviations from SW-846[a]

Analysis	Method		SW 846 specification	Deviation from SW 846	Rationale for deviation
1 Continuous Liquid/ Liquid Extraction	3520	A	The internal standards are prepared by dissolving them in carbon disulfide and then diluting to volume so that the final solvent is 20% carbon disulfide and 80% methylene chloride	The preparation of the internal standards was changed to eliminate the use of carbon disulfide. The internal standards were prepared in methylene chloride only	
		B	The extracts are concentrated to a final volume of 1-2 ml	Due to the high organic content in many samples, the extracts could not be reduced to the 1-2 ml final volume. The increased sample volume in the extract was taken into account when the dilutions were made and when the concentrations values were calculated. Final sample volume varied depending upon the sample. However, for most samples the final volume was 6-7 ml. For sample point 3, the final volume was 75-100 ml.	Final volume of sample extracts was increased to keep all organic material in solution. When the final volume was decreased, the samples crystallized.
		C	The samples are extracted initially (base/neutral) extracted at pH >11 and the secondary (acid) extraction is at pH <2	For samples from SD3, SD4, and SD10, the acid extraction was completed first, followed by the base/neutral extraction	The acid extraction was completed first due to the acidity of the samples. The pHs for these samples were between 0 and 2. Therefore, to prevent potential sample contamination and to prevent adding large volumes of acid and base solution to change the pH to basic and then back to acidic, the acid extraction was completed first. The pH of samples from Sample Point 11 could not be raised to pH 11 (200 ml of NaOH were added to the

Table E-2 (Continued)

Analysis	Method	SW-846 specification	Deviation from SW-846	Rationale for deviation
1 Continuous Liquid/ Liquid Extraction (Continued)				filter sample and the pH did not change from the initial pH of zero.)
		b The samples are extracted for base/neutral and for acid extractables	For SD 10, the one sample taken was extracted for the acid extraction only.	The sample contained about 60% nitrobenzene, therefore, to obtain information on the presence of the acid extractable compounds, the analysis was completed only on the acid extractables. The high quantity of nitrobenzene in the base/neutral fraction would have required extremely high dilution of the material to prevent column saturation and to bring the concentration level into the ppb linear range of the method. Therefore, only the level of nitrobenzene could have been quantified.

a - Onsite Engineering Report of Treatment Technology Performance for E. I. duPont de Nemours, Inc., Beaumont, Texas. Table 7-4.

Table E-3 Specific Procedures or Equipment Used in Extraction of Organic Compounds When Alternatives or Equivalents are Allowed in the SW-846 Methods[a]

Analysis	SW-846 Method	Sample Aliquot	Alternatives or Equivalents Allowed by SW-846 Methods	Specific Procedures or Equipment Used
Purge and Trap	5030	5 milliliters of liquid	• The purge and trap device to be used is specified in the method in Figure 1, the desorber to be used is described in Figures 2 and 3, and the packing materials are described in Section 4.10.2. The method allows equivalents of this equipment or materials to be used.	• The purge and trap equipment and the desorber used were as specified in SW-846. The purge and trap equipment is a Teckmar LSC-2 with standard purging chambers (Supelco cat. 2-0293). The packing materials for the traps were 1/3 silica gel and 2/3 2,6-diphenylene.
			• The method specifies that the trap must be at least 25 cm long and have an inside diameter of at least 0.105 in.	• The length of the trap was 30 cm and the diameter was 0.105 cm.
			• The surrogates recommended are toluene-d8,4-bromofluorobenzene, and 1,2-dichloroethane-d4. The recommended concentration level is 50 ug/l.	• The surrogates were added as specified in SW-846.
Continuous Liquid-Liquid Extraction	3520	1 liter of liquid	• Acid and base/neutral extracts are usually combined before analysis by GC/MS. However, under some situations, they may be extracted and analyzed separately.	• Acid and base/neutral extracts were combined.
			• The base/neutral surrogates recommended are 2-fluorobiphenyl, nitrobenzene-d5, terphenyl-d14. The acid surrogates recommended are 2-fluorophenol, 2,4,6-tribromophenol, and phenol-d6. Additional compounds	• Surrogates were the same as those recommended by SW-846. The volume of the surrogates added was increased due to the sample matrix. All samples except, the one sample from Sample Point 10 had 3 ml of the surrogates containing 100 ppm of the

Table E-3 (Continued)

Analysis	SW-846 Method	Sample Aliquot	Alternatives or Equivalents Allowed by SW 846 Methods	Specific Procedures or Equipment Used
Continuous Liquid-Liquid Extraction (Continued)			may be used for surrogates. The recommended concentrations for low-medium concentration level samples are 100 ppm for acid surrogates and 200 ppm for base/neutral surrogates. Volume of surrogate may be adjusted.	base neutral surrogate and 200 ppm of the acid surrogates added. To the one sample from Sample Point 10, 10 ml of the surrogates were added.

a - Onsite Engineering Report of Treatment Technology Performance for E. I. duPont de Nemours, Inc., Beaumont, Texas. Table 7-5.

Table E-4 Special Procedures or Equipment Used for Analysis of Organic Compounds When Alternatives or Equivalents are Allowed in the SW-846 Methods[a]

Analysis	SW 846 Method	Sample Preparation Method	Alternatives or Equivalents Allowed in SW-846 for Equipment or in Procedure		Specific Equipment or Procedures Used	
			Recommended GC/MS operating conditions		Actual GC/MS operating conditions	
Gas Chromatography/ Mass Spectrometry for volatile organics	8240	5030	Electron energy	70 vols (nominal)	Electron energy:	70 ev
			Mass range	35-260 amu	Mass range:	35 - 260 amu
			Scan time	To give 5 scans/peak but not to exceed 7 sec/scan	Scan time	2.5 sec/scan
			Initial column temperature:	45°C	Initial column temperature:	38°C
			Initial column holding time:	3 min	Initial column holding time:	2 min
			Column temperature program:	8°C/min	Column temperature program:	10°C/min
			Final column temperature:	200°C	Final column temperature:	225°C
			Final column holding time:	15 min	Final column holding time:	30 min or xylene elutes
			Injector temperature:	200-225°C	Injector temperature:	225°C
			Source temperature:	According to manufacturer's specification	Source temperature:	100°C
			Transfer line temperature:	250-300°C	Transfer line temperature:	275°C
			Carrier gas:	Hydrogen at 50 cm/sec or helium at 30 cm/sec	Carrier gas:	Helium @ 30 ml/min.
					•Additional Information on Actual System Used Equipment: Finnegan model 5100 GC/MS/DS system Data system: SUPERINCOS Autoquan Mode: Electron Impact NBS library available Interface to MS - Jet separator	
			• The column should be 6-ft × 0.1 in. I.D. glass, packed with 1% SP-1000 on Carbopack B (60/80 mesh) or an equivalent		• The column used was an 8-ft. × 0.1 in. I.D. glass, packed with 1% SP-1000 on Carbopack B (60/80 mesh)	
			• Samples may be analyzed by purge and trap technique or by direct injection		• All samples were analyzed using the purge and trap technique	

Table E-4 (Continued)

Analysis	SW 846 Method	Sample Preparation Method	Alternatives or Equivalents Allowed in SW 846 for Equipment or in Procedure		Specific Equipment or Procedures Used	
			Recommended GC/MS operating conditions		Actual GC/MS operating conditions	
Gas Chromatography/ Mass Spectrometry for semivolatile organics: capillary column technique	8270	3520-Liquids	Mass range	35-500 amu	Mass range:	35 - 500 amu
			Scan time	1 sec/scan	Scan time:	1 sec/scan
			Initial column temperature	40°C	Initial column temperature:	30°C
			Initial column holding time	4 min	Initial column holding time:	4 min
			Column temperature program:	40-270 C at 10°C/min	Column temperature program:	8°C/min to 275° and 10°C/min until 305°C
			Final column temperature hold	270°C (until benzo[g,h,i,]perylene has eluted)	Final column temperature hold:	305°C
			Injector temperature	250-300°C	Injector temperature:	240-260°C
			Transfer line temperature	250-300°C	Transfer line temperature:	300°C
			Source temperature	According to manufacturer's specification	Source temperature:	Non-heated
			Injector	Grob-type, splitless	Injector:	Grob-type, spitless
			Sample volume	1-2 ul	Sample volume	1 ul of sample extract
			Carrier gas:	Hydrogen at 50 cm/sec or helium at 30 cm/sec	Carrier gas:	Helium @ 40 cm/sec.
			• The column should be 30 m by 0.25 mm I.D., 1-um film thickness silicon-coated fused silica capillary column (J&W Scientific DB-5 or equivalent)		•Additional Information on Actual System Used: Equipment: Finnegan model 5100 GC/MS/DS system Software Package: SUPERINCOS AUTOQUAN The column used was a 30 m x 0.32 mm I.D. RT_x -5 (5% phenyl methyl silicone) FSCC	

a - Onsite Engineering Report of Treatment Technology Performance for E. I. duPont de Nemours, Inc., Beaumont, Texas. Table 7-6.

Table E-5 Specific Procedures or Equipment Used for Analysis of Cyanides When Alternatives or Equivalents are Allowed in the SW-846 Methods[a]

Analysis	SW-846 Method	Sample Aliquot	Alternatives or Equivalent Allowed by SW-846 Methods	Specific Procedures Used
Total and amenable cyanide	9012	500 ml	Hydrogen sulfide treatment may be required.	Hydrogen sulfide treatment was not required.
			A Fisher-Mulligan absorber or equivalent should be used	A Wheaton Distilling Apparatus absorber was used.

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[a] - Onsite Engineering Report of Treatment Technology Performance for E. I. duPont de Nemours, Inc., Beaumont, Texas. Table 7-8.

Table E-6 Matrix Spike Recoveries for Treated Waste[a]

BDAT Constituent	Original Amount Found (ug/L)	Sample Set[+]			Sample Set Duplicate[+]			Accuracy Factor**
		Spike Added (ug/L)	Spike Result (ug/L)	Percent Recovery*	Spike Added (ug/L)	Spike Result (ug/L)	Percent Recovery*	
Volatile								
4. Benzene	18	50	56	76	50	65	94	1.32
Semivolatile								
56. Aniline	ND	200	194	97	200	182	91	1.10
101. 2,4-Dinitrophenol***	---	---	---	85	---	---	80	1.25
126. Nitrobenzene	ND	200	232	116	200	229	115	0.87
142. Phenol	ND	200	63	21	200	51	26	4.76
Inorganics								
169. Total Cyanides[++]	129	100	201	72	---	---	---	1.39

a = From Onsite Engineering Report of Treatment Technology Performance for E. I. du Pont de Nemours, Inc., Beaumont, Texas. Tables 7-12 through 7-14.

*Percent Recovery = [(Spike Result - Original Amount)/Spike Amount)] x 100.

**Accuracy Correction Factor = 100/(Percent Recovery), using the lower of the two percent recovery values.

ND = Not detected. Value assumed to be zero in calculation for percent recovery.

*** = The matrix spike recovery values presented for 2,4-Dinitrophenol are actually the average of the percent recoveries greater than 20% for all semivolatiles.

+ = For the matrix spike recoveries presented: Volatiles from Sample Set 3(even though this sample set was deleted from the final development of treatment standards, the matrix spike recoveries were not affected.), Semivolatiles from Sample Set 1, and Inorganics from Sample Set 4.

++ = Total cyanides are regulated for K104 only.

APPENDIX F

METHOD OF MEASUREMENT FOR THERMAL CONDUCTIVITY

The comparative method of measuring thermal conductivity has been proposed as an ASTM test method under the name "Guarded, Comparative, Longitudinal Heat Flow Technique." A thermal heat flow circuit is used that is the analog of an electrical circuit with resistances in series. A reference material is chosen to have a thermal conductivity close to that estimated for the sample. Reference standards (also known as heat meters) having the same cross-sectional dimensions as the sample are placed above and below the sample. An upper heater, a lower heater, and a heat sink are added to the "stack" to complete the heat flow circuit. See Figure F-1.

The temperature gradients (analogous to potential differences) along the stack are measured with type K (chromel/alumel) thermocouples placed at known separations. The thermocouples are placed into holes or grooves in the references and also in the sample whenever the sample is thick enough to accommodate them.

For molten samples, pastes, greases, and other materials that must be contained, the material is placed into a cell consisting of a top and bottom of Pyrex 7740 and a containment ring of marinite. The sample is 2 inches in diameter and 0.5 inch thick. Thermocouples are not placed into the sample; rather, the temperatures measured in the Pyrex disks are extrapolated to give the temperature at the top and bottom surfaces of the sample material. The Pyrex disks also serve as the thermal conductivity reference material.

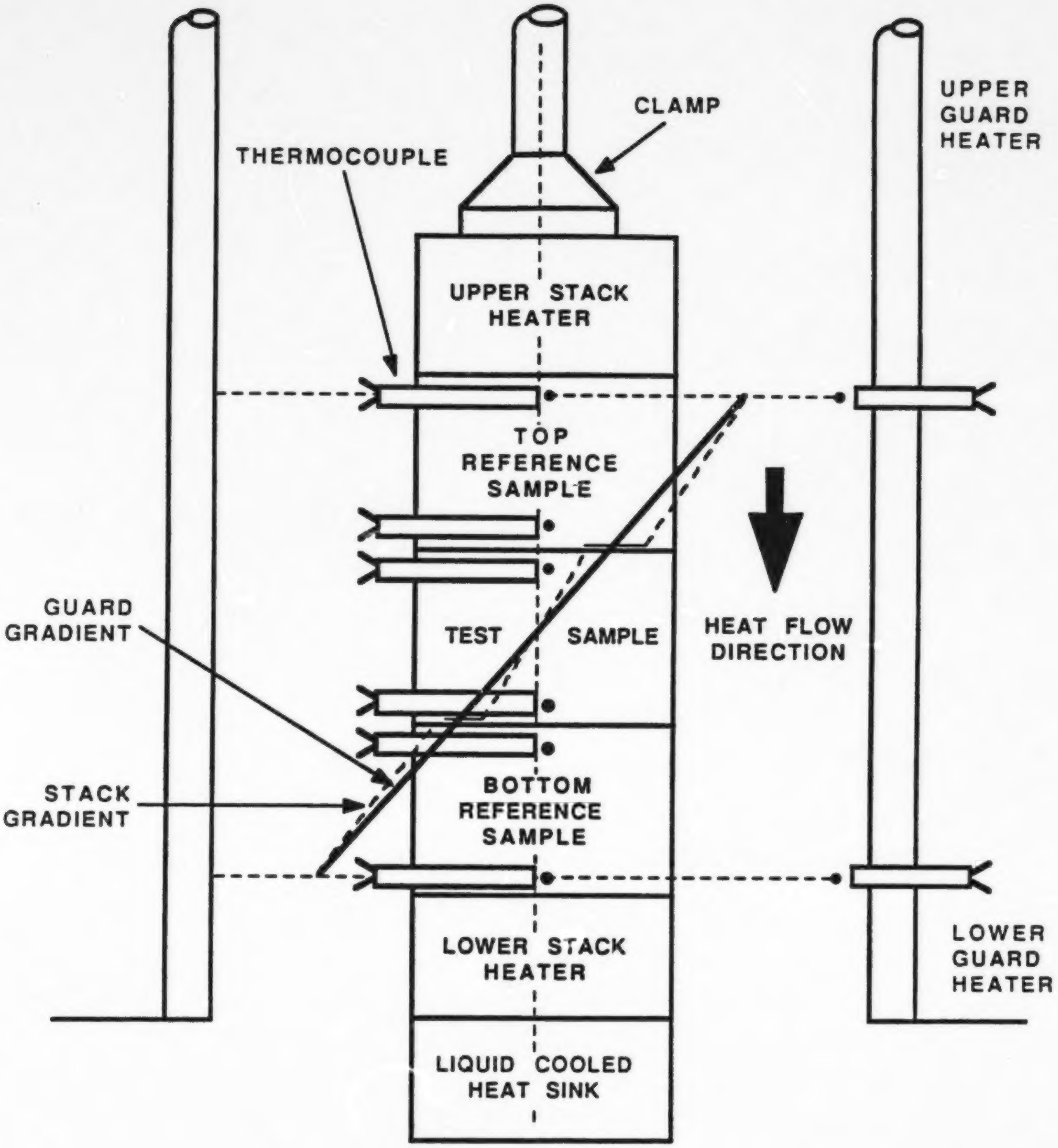
UPPER GUARD HEATER
CLAMP
THERMOCOUPLE
UPPER STACK HEATER
TOP REFERENCE SAMPLE
GUARD GRADIENT
TEST SAMPLE
HEAT FLOW DIRECTION
STACK GRADIENT
BOTTOM REFERENCE SAMPLE
LOWER STACK HEATER
LOWER GUARD HEATER
LIQUID COOLED HEAT SINK

FIGURE F-1 SCHEMATIC DIAGRAM OF THE COMPARATIVE METHOD

The stack is clamped with a reproducible load to ensure intimate contact between the components. To produce a linear flow of heat down the stack and reduce the amount of heat that flows radially, a guard tube is placed around the stack and the intervening space is filled with insulating grains or powder. The temperature gradient in the guard is matched to that in the stack to further reduce radial heat flow.

The comparative method is a steady-state method of measuring thermal conductivity. When equilibrium is reached, the first flux (analogous to current flow) down the stack can be determined from the references. The heat into the sample is given by

$$\dot{Q}_{in} = \lambda_{top}(dT/dx)_{top}$$

and the heat out of the sample is given by

$$Q_{out} = \lambda_{bottom}(dT/dx)_{bottom}$$

where

λ = thermal conductivity

dT/dx = temperature gradient

and top refers to the upper reference, while bottom refers to the lower reference. If the heat was confined just to flow down the stack, then Q_{in} and Q_{out} would be equal. If Qin and Q_{out} are in reasonable agreement, the average heat flow is calculated from

$$Q = (Q_{in} + Q_{out})/2.$$

The sample **thermal** conductivity is then found from

$$\lambda_{sample} = Q/(dT/dx)_{sample}.$$

The result for the K102 Activated Charcoal Waste tested is given in Table F-1. The sample was held at an average temperature of 42°C, with a 53°C temperature drop across the sample for approximately 20 hours before the temperature profile became steady and the conductivity was measured. At the conclusion of the test, it appeared that some "drying" of the sample had occurred.

The result for the K101 waste tested is given in Table F-1. The sample was held at an average temperature of 39°C, with a 39°C temperature drop across the sample for approximately 4 hours before the temperature profile became steady and the conductivity was measured. At the conclusion of the test, it appeared that some "drying" of the sample had occurred. Bubbles had formed in the sample and had migrated to the top of the sample in contact with the upper reference. Approximately 15 percent of the upper Pyrex reference was not in contact with the sample when thermal equilibrium was reached. Thus, the conductivity given in Table F-1 may be low by 5 to 10 percent.

Table F-1 The Results of the Measurement of the Thermal Conductivity Using the Comparative Method

Sample	Temperature	Thermal Conductivity
	(°C)	(W/mK)*
K101 Waste	39	.273
K102 Activated Charcoal Waste	42	.136

*1 W/mK = 6.933 Btu in/h ft^2 F = .5778 Btu/h ft F

APPENDIX G

STRIP CHARTS

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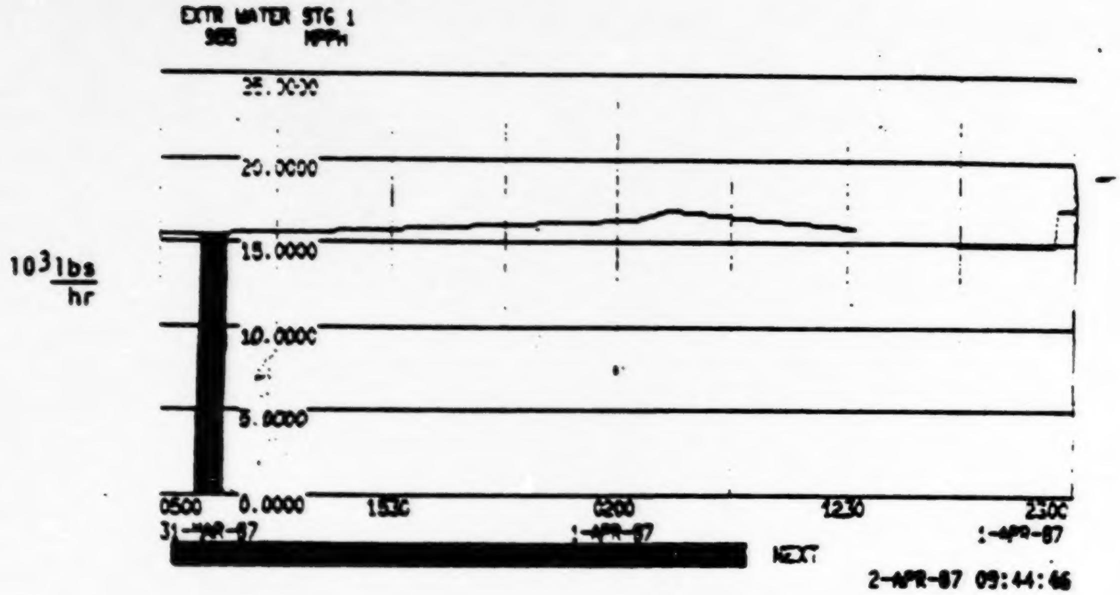
SAMPLE SET #1
March 31, 1987

7:00 - 8:00 AM

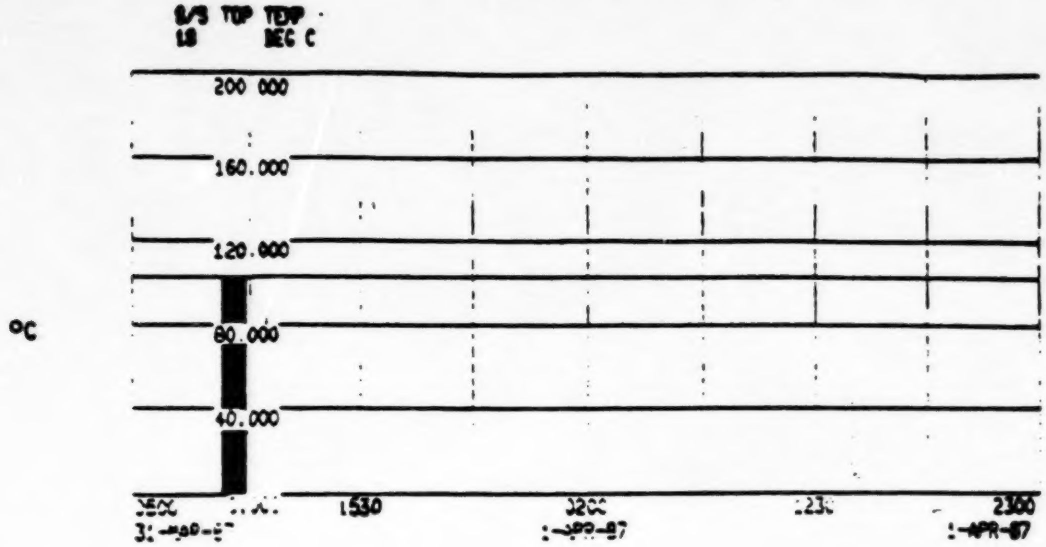


FEED RATE TO THE ANILINE LIQUID/LIQUID EXTRACTOR

FIGURE G-1 RECORDING CHARTS FOR K103: SAMPLE SET #1

SAMPLE SET #1
March 31, 1987

9:00 - 10:00 AM



STEAM STRIPPER TOP COLUMN TEMPERATURE

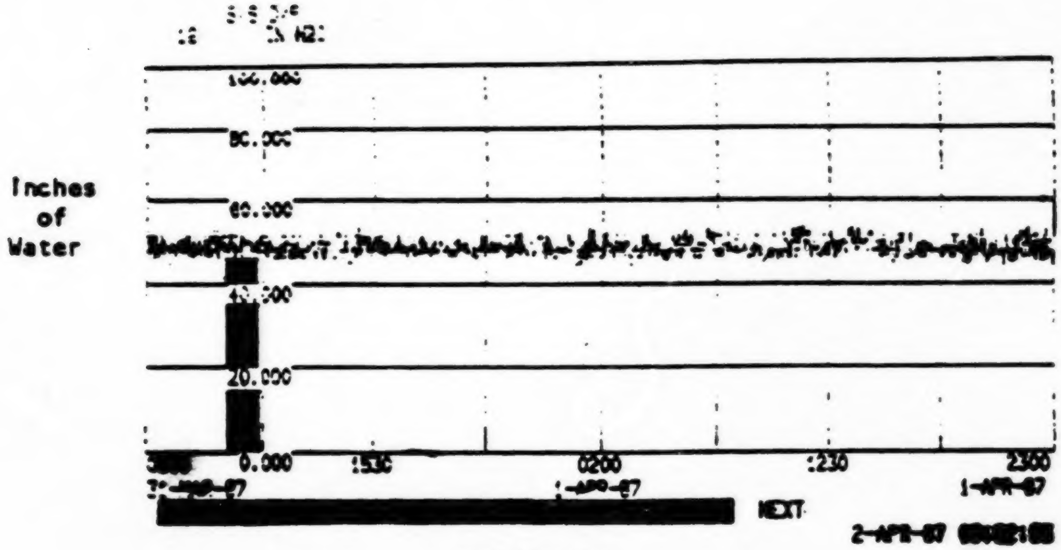
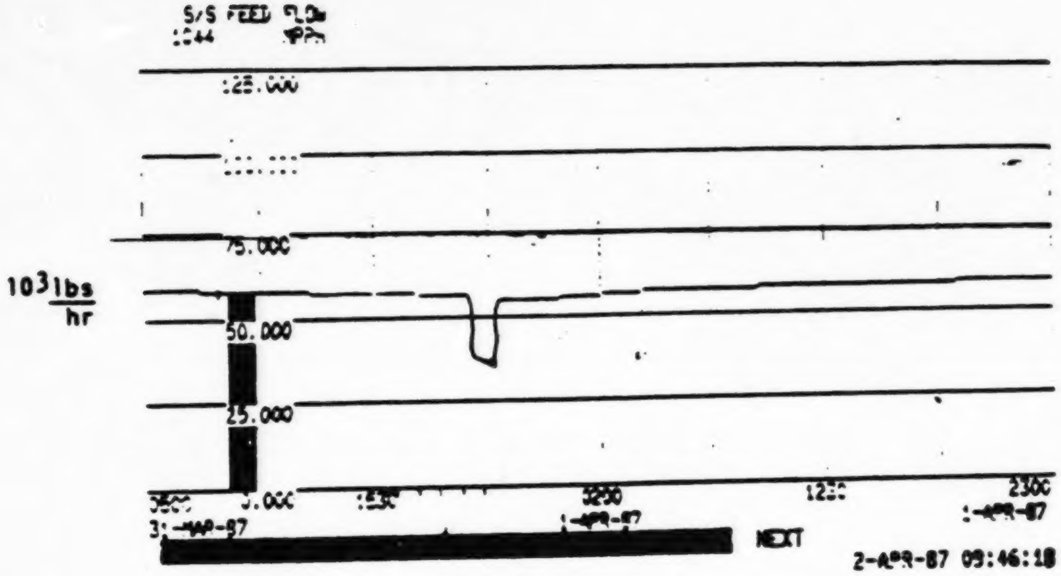


FIGURE II-5
PRESSURE DROP ACROSS THE STEAM STRIPPER COLUMN

FIGURE G-1 RECORDING CHARTS FOR K103: SAMPLE SET #1 (Continued)

SAMPLE SET #1
March 31, 1987

9:00 - 10:00 AM

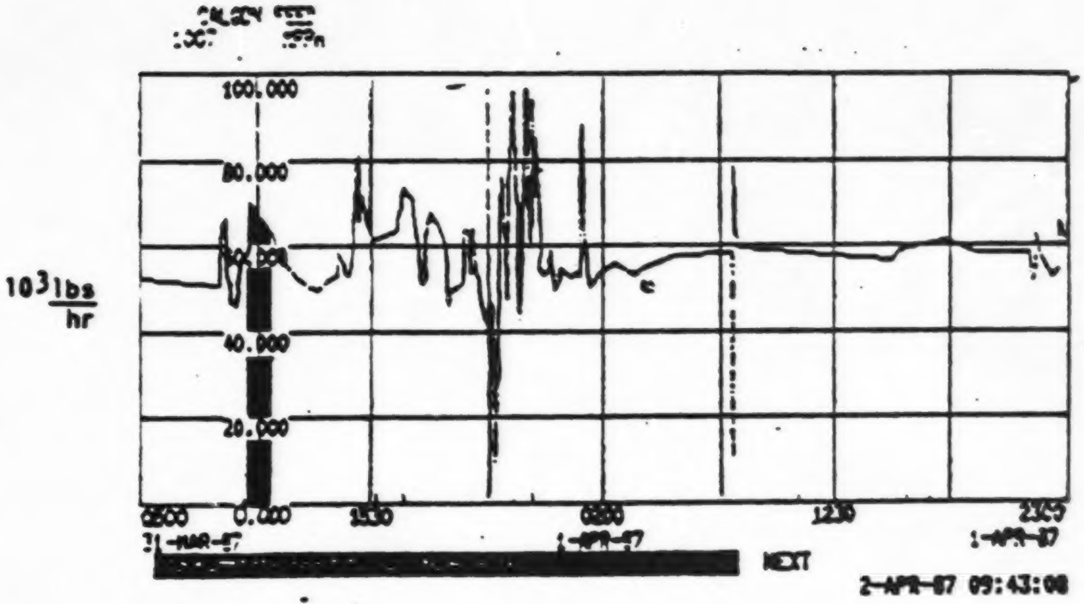


FEED RATE TO THE STEAM STRIPPER

FIGURE G-1 RECORDING CHARTS FOR K103: SAMPLE SET #1 (Continued)

SAMPLE SET #1
March 31, 1987

10:00 - 11:00 AM

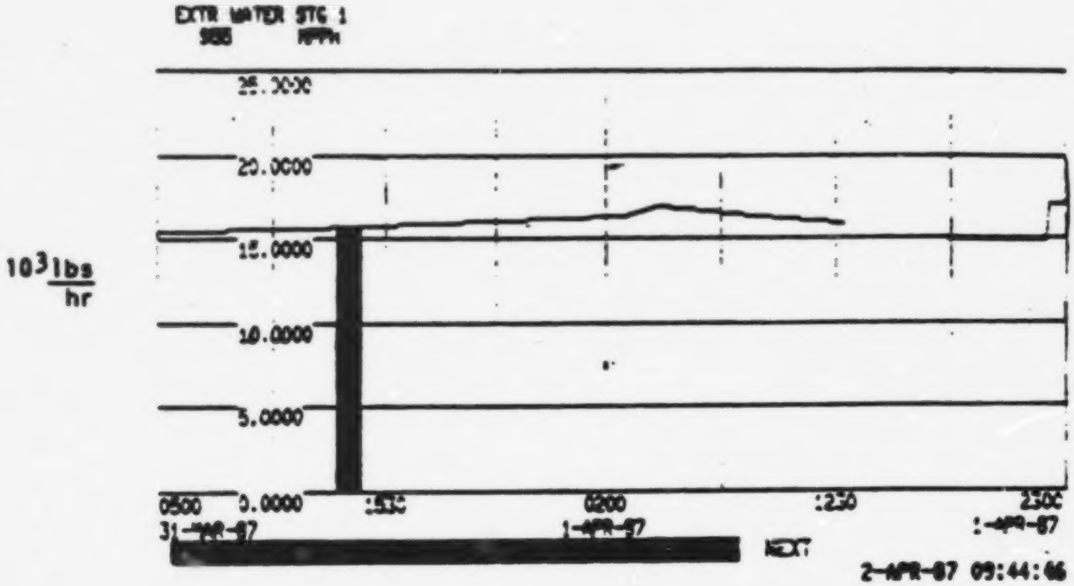


FEED RATE TO THE CARBON ADSORPTION SYSTEM

FIGURE G-1 RECORDING CHARTS FOR K103: SAMPLE SET #1 (Continued)

SAMPLE SET #2
March 31, 1987

1:00 - 2:00 PM

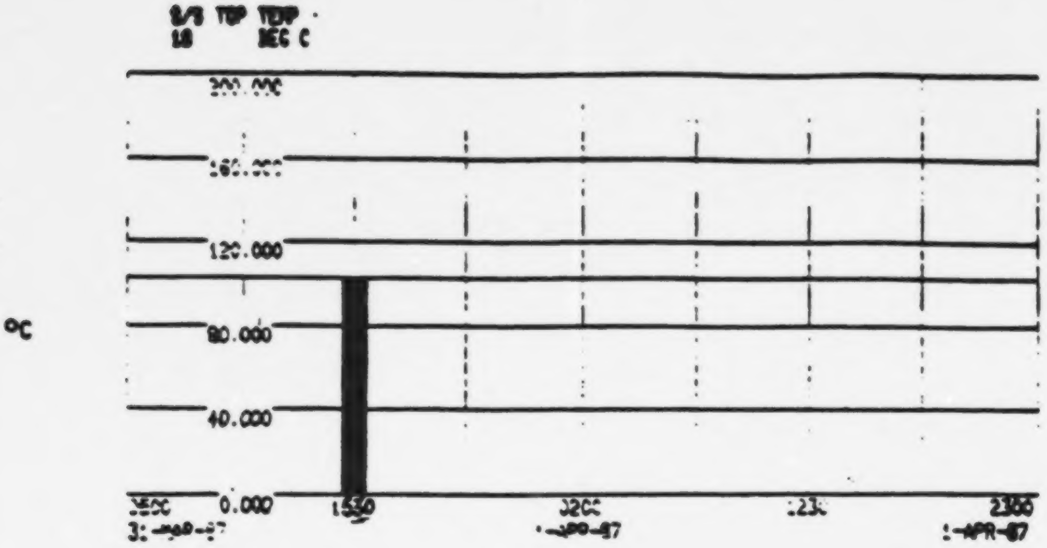


FEED RATE TO THE ANILINE LIQUID/LIQUID EXTRACTOR

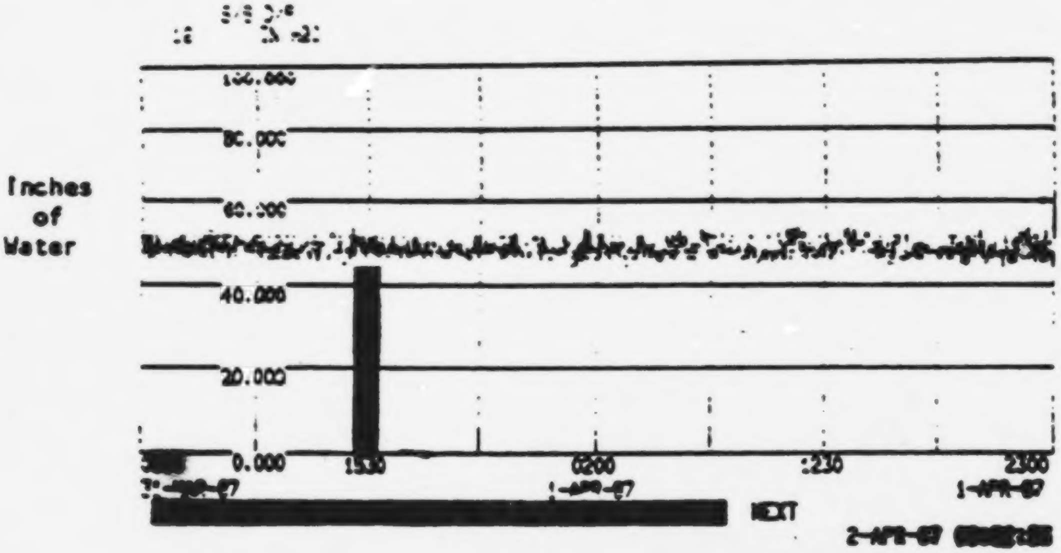
FIGURE G-2 RECORDING CHARTS FOR K103: SAMPLE SET #2

SAMPLE SET #2
March 31, 1987

3:00 - 4:00 PM



STEAM STRIPPER TOP COLUMN TEMPERATURE

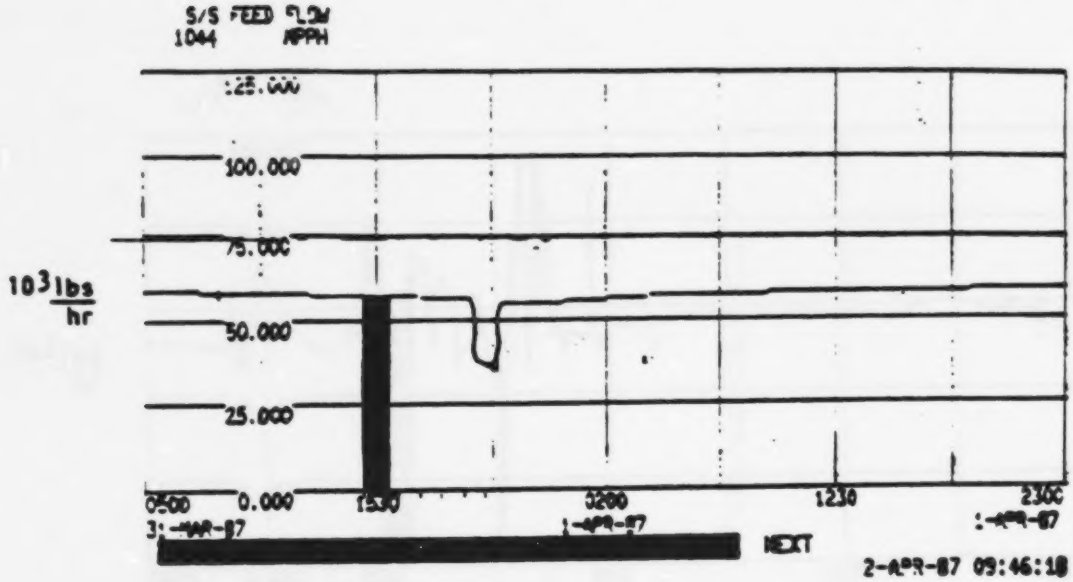


PRESSURE DROP ACROSS THE STEAM STRIPPER COLUMN

FIGURE G-2 RECORDING CHARTS FOR K103: SAMPLE SET #2 (Continued)

SAMPLE SET #2
March 31, 1987

3:00 - 4:00 PM

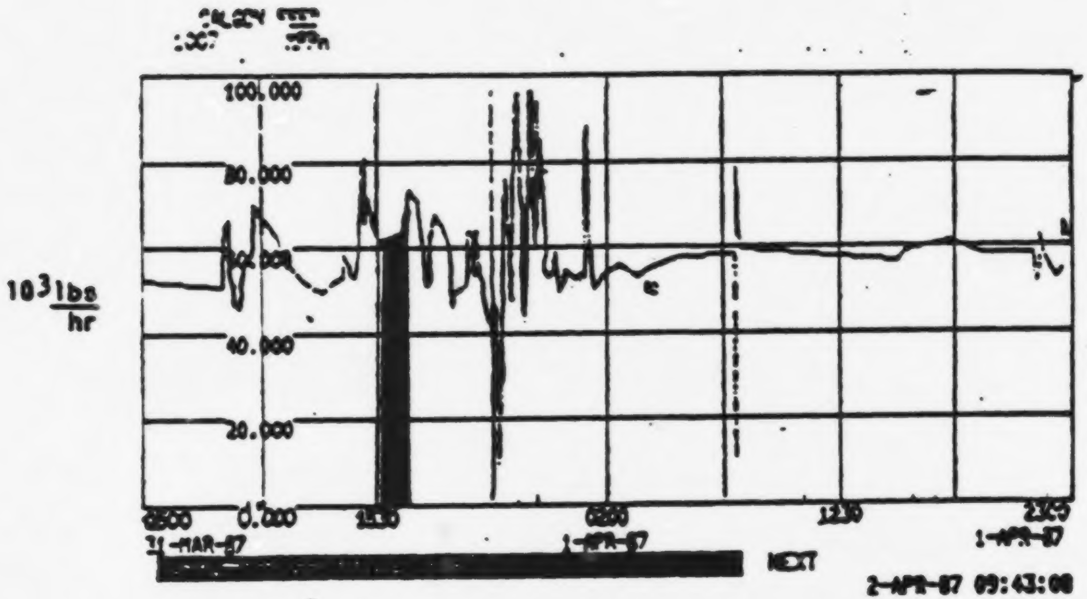


FEED RATE TO THE STEAM STRIPPER

FIGURE G-2 **RECORDING CHARTS FOR K103: SAMPLE SET #2 (Continued)**

SAMPLE SET #2
March 31, 1987

4:00 - 5:00 PM

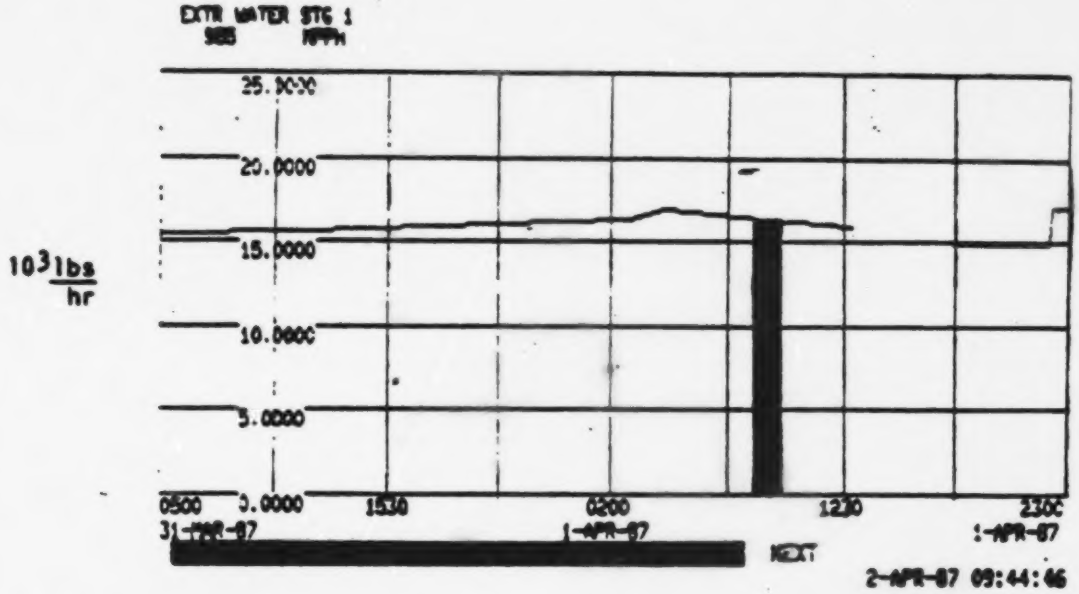


FEED RATE TO THE CARBON ADSORPTION SYSTEM

FIGURE G-2 RECORDING CHARTS FOR K103: SAMPLE SET #2 (Continued)

SAMPLE SET #3
April 1, 1987

7:00 - 8:00 AM

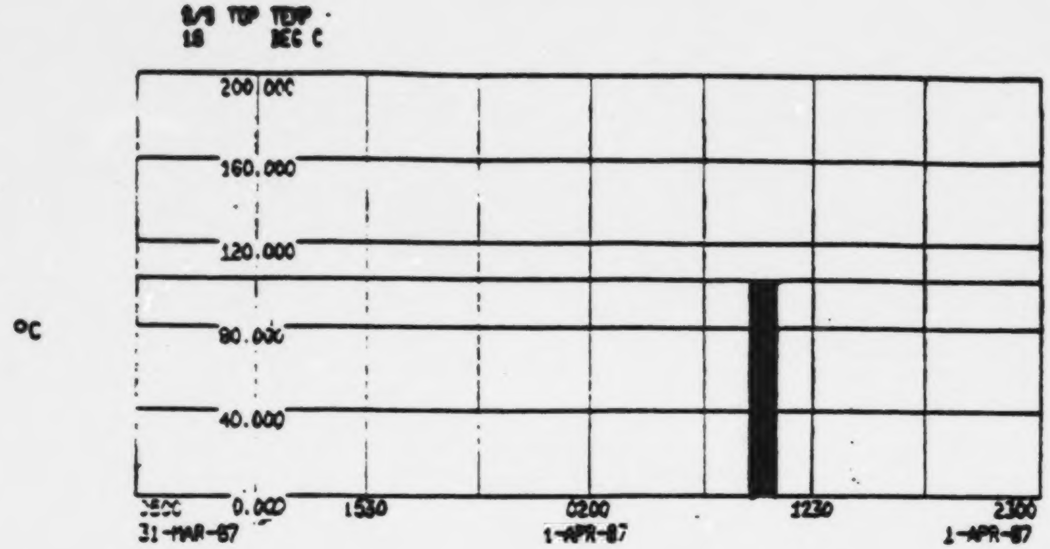


FEED RATE TO THE ANILINE LIQUID/LIQUID EXTRACTOR

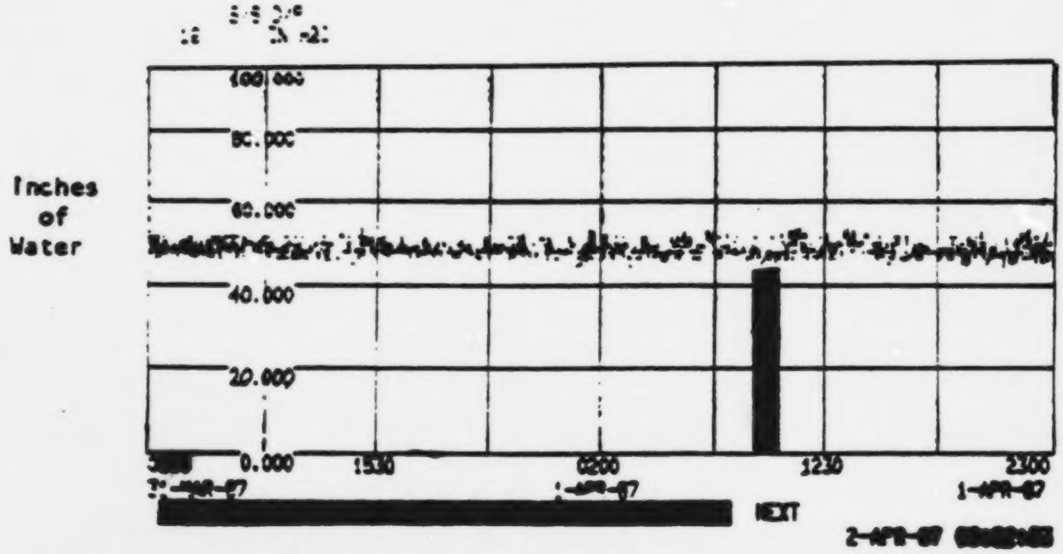
FIGURE G-3 RECORDING CHARTS FOR K103: SAMPLE SET #3

SAMPLE SET #3
April 1, 1987

9:00 - 10:00 AM



STEAM STRIPPER TOP COLUMN TEMPERATURE



PRESSURE DROP ACROSS THE STEAM STRIPPER COLUMN

FIGURE G-3 RECORDING CHARTS FOR K103: SAMPLE SET #3 (Continued)

SAMPLE SET #3
April 1, 1987

9:00 - 10:00 AM

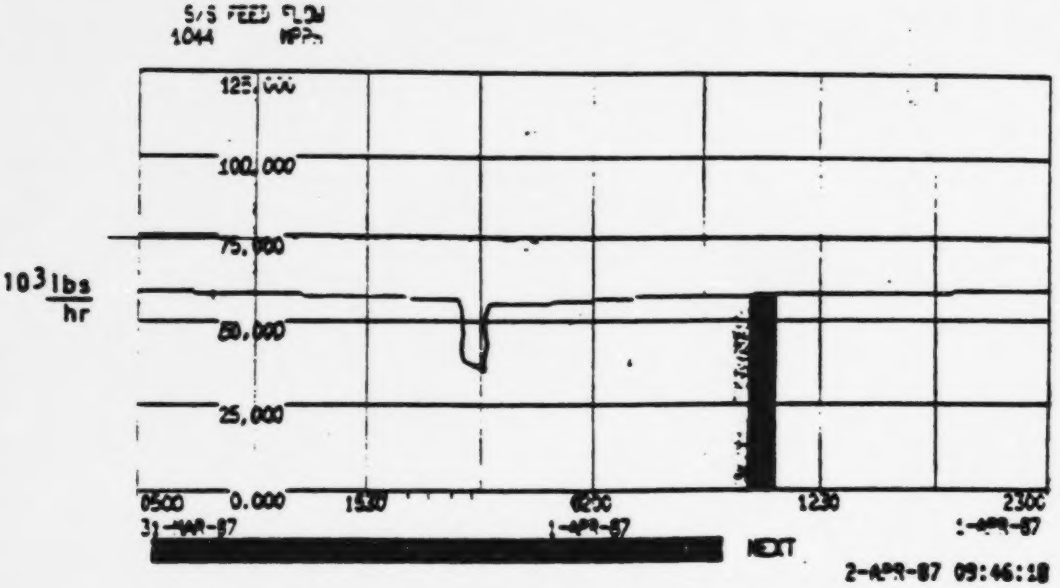
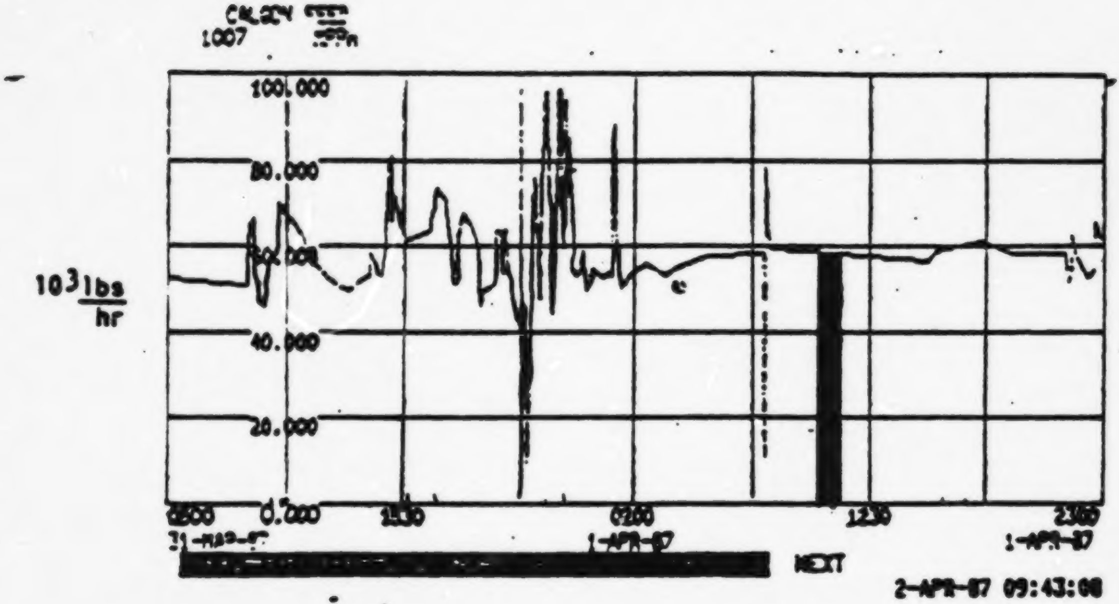


FIGURE 11-8
FEED RATE TO THE STEAM STRIPPER

FIGURE G-3 RECORDING CHARTS FOR K103: SAMPLE SET #3 (Continued)

SAMPLE SET #3
April 1, 1987

10:00 - 11:00 AM

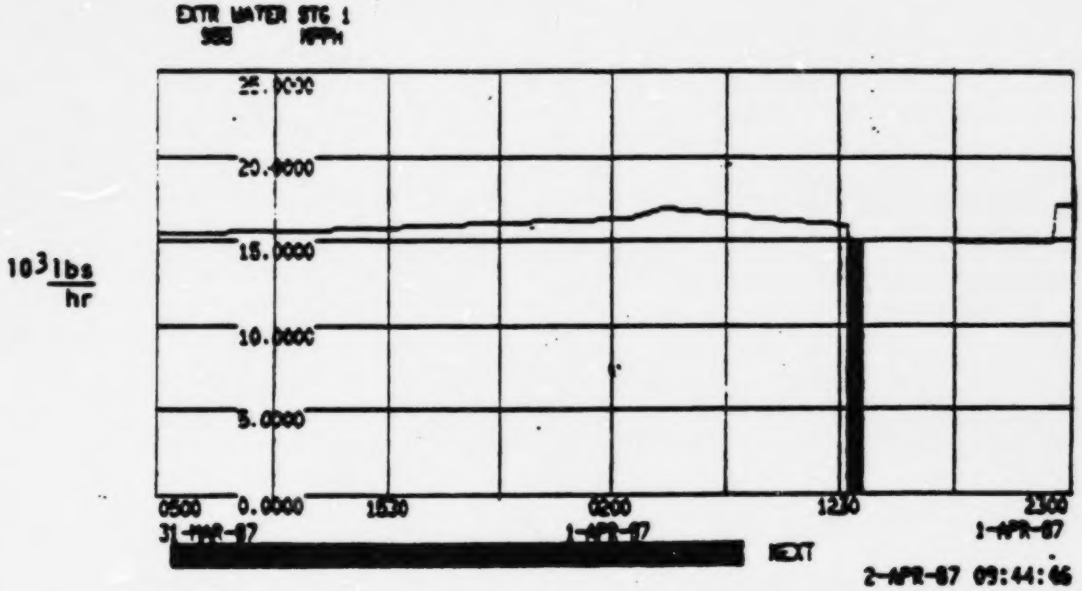


FEED RATE TO THE CARBON ADSORPTION SYSTEM

FIGURE G-3 RECORDING CHARTS FOR K103: SAMPLE SET #3 (Continued)

SAMPLE SET #4
April 1, 1987

1:00 - 2:00 PM

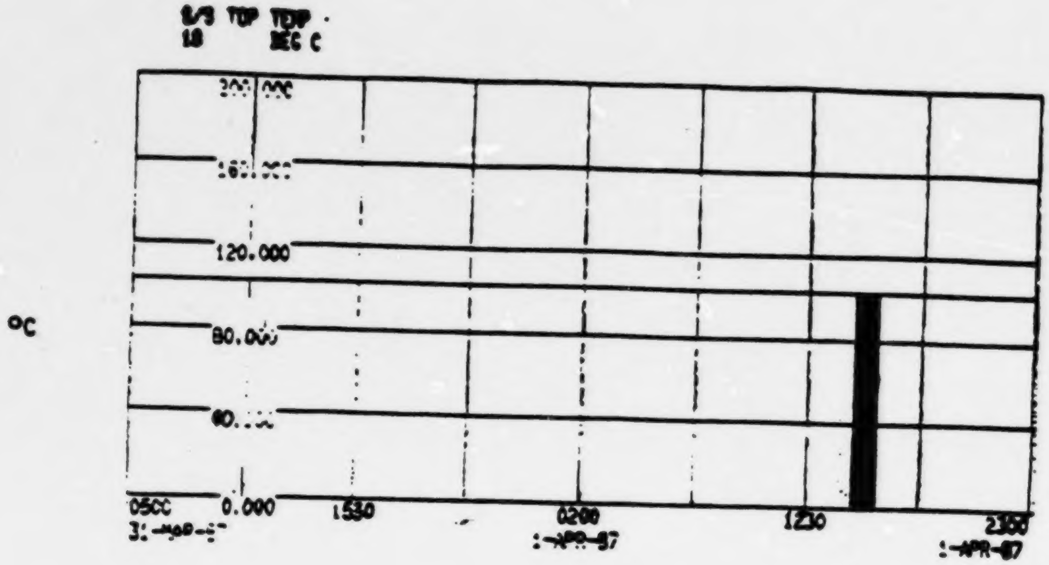


FEED RATE TO THE ANILINE LIQUID/LIQUID EXTRACTOR

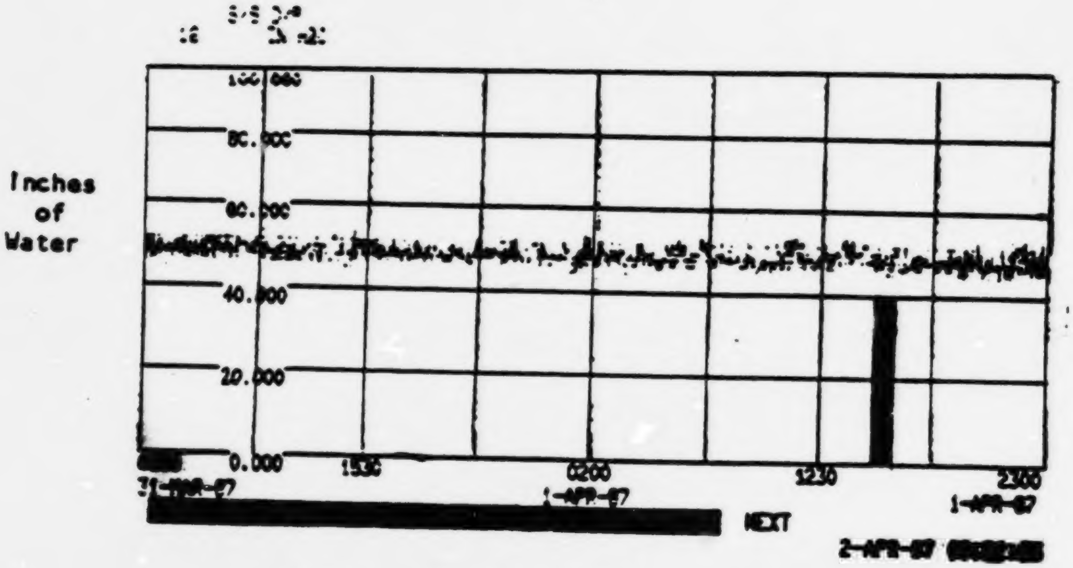
FIGURE G-4 RECORDING CHARTS FOR K103: SAMPLE SET #4

SAMPLE SET #4
April 1, 1987

3:00 - 4:00 PM



STEAM STRIPPER TOP COLUMN TEMPERATURE

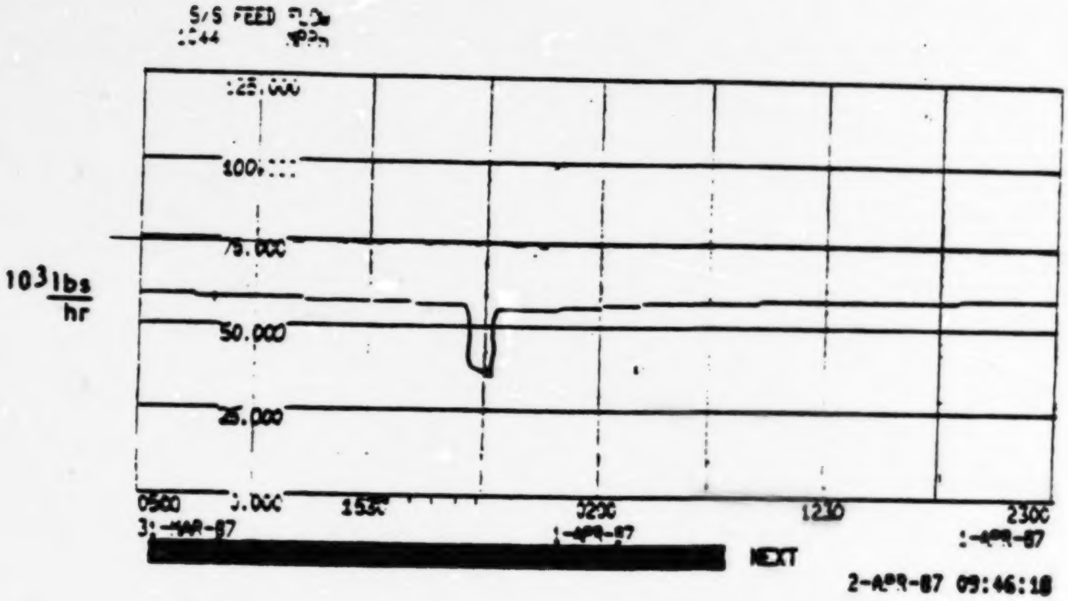


PRESSURE DROP ACROSS THE STEAM STRIPPER COLUMN

FIGURE G-4 RECORDING CHARTS FOR K103: SAMPLE SET #4 (Continued)

SAMPLE SET #4
April 1, 1987

3:00 - 4:00 PM

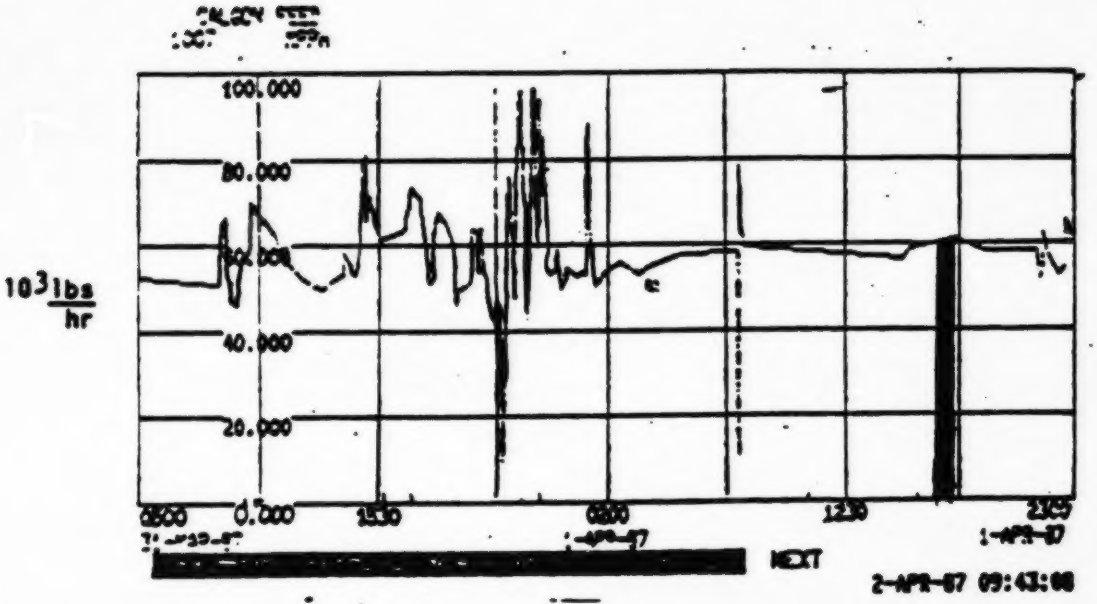


FEED RATE TO THE STEAM STRIPPER

FIGURE G-4 RECORDING CHARTS FOR K103: SAMPLE SET #4 (Continued)

SAMPLE SET #4
April 1, 1987

4:00 - 5:00 PM

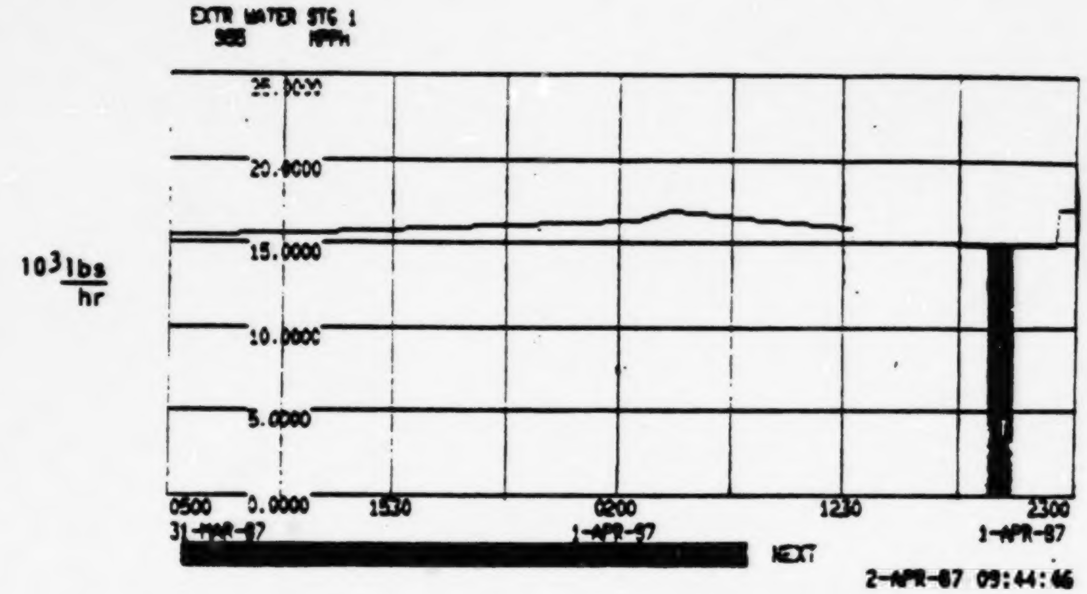


FEED RATE TO THE CARBON ADSORPTION SYSTEM

FIGURE G-4 RECORDING CHARTS FOR K103: SAMPLE SET #4 (Continued)

SAMPLE SET #5
April 1, 1987

7:00 - 8:00 PM

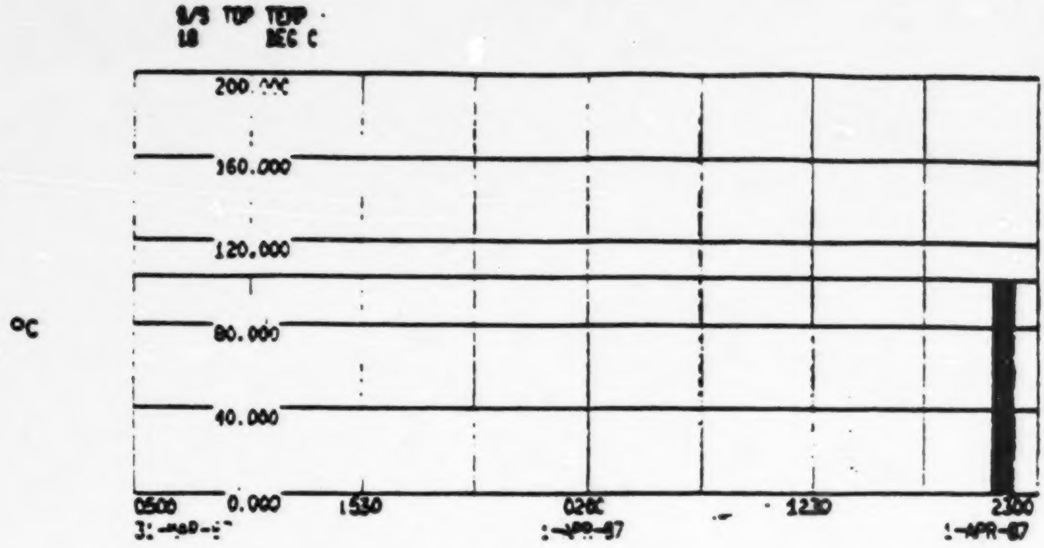


FEED RATE TO THE ANILINE LIQUID/LIQUID EXTRACTOR

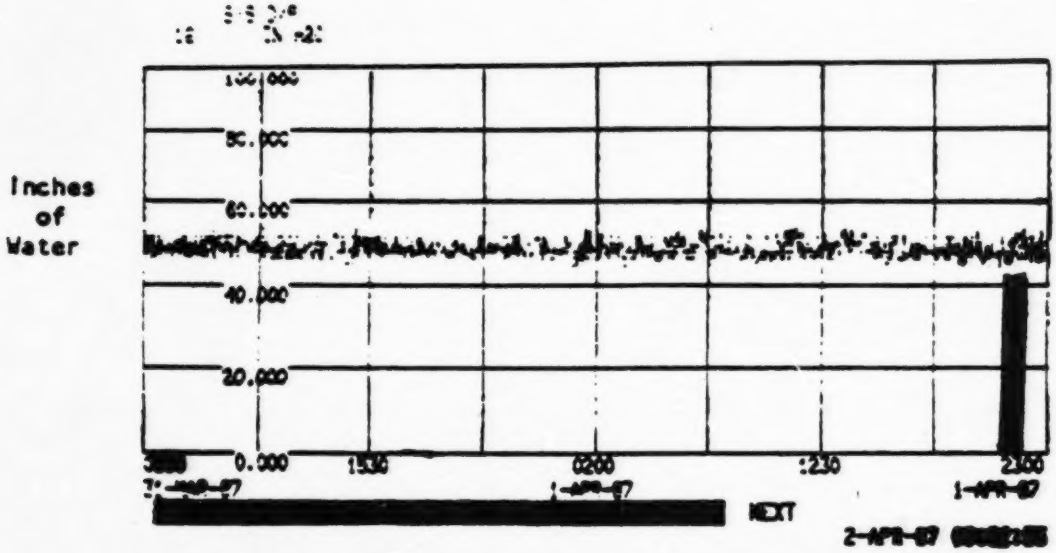
FIGURE G-5 RECORDING CHARTS FOR K103: SAMPLE SET #5

SAMPLE SET #5
April 1, 1987

9:00 - 10:00 PM



STEAM STRIPPER TOP COLUMN TEMPERATURE

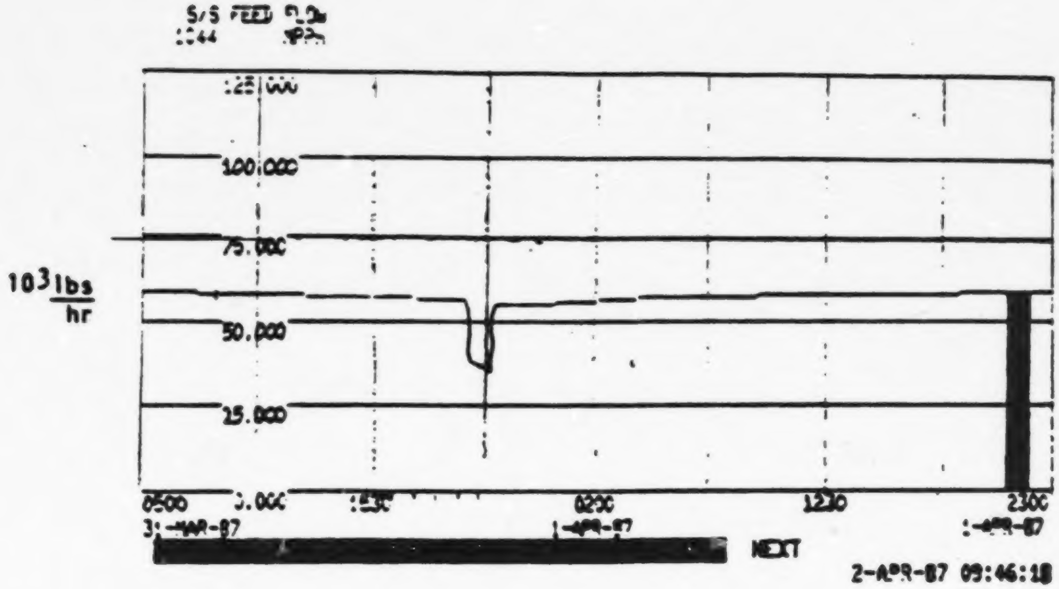


PRESSURE DROP ACROSS THE STEAM STRIPPER COLUMN

FIGURE G-5 RECORDING CHARTS FOR K103: SAMPLE SET #5 (Continued)

SAMPLE SET #5
April 1, 1987

9:00 - 10:00 PM

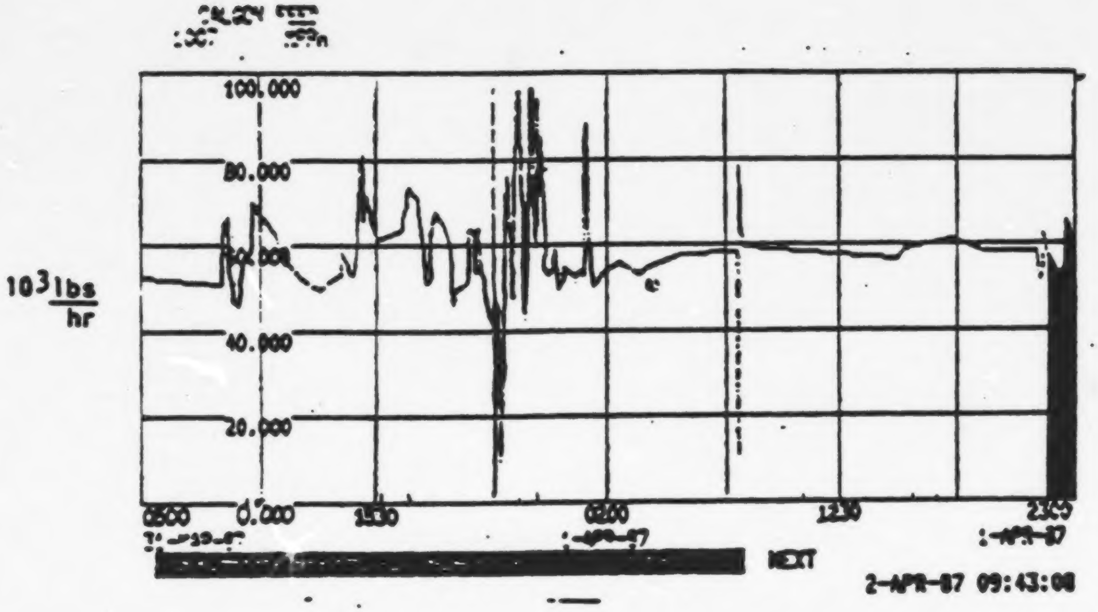


FEED RATE TO THE STEAM STRIPPER

FIGURE G-5 RECORDING CHARTS FOR K103: SAMPLE SET #5 (Continued)

SAMPLE SET #5
April 1, 1987

10:00 - 11:00 PM

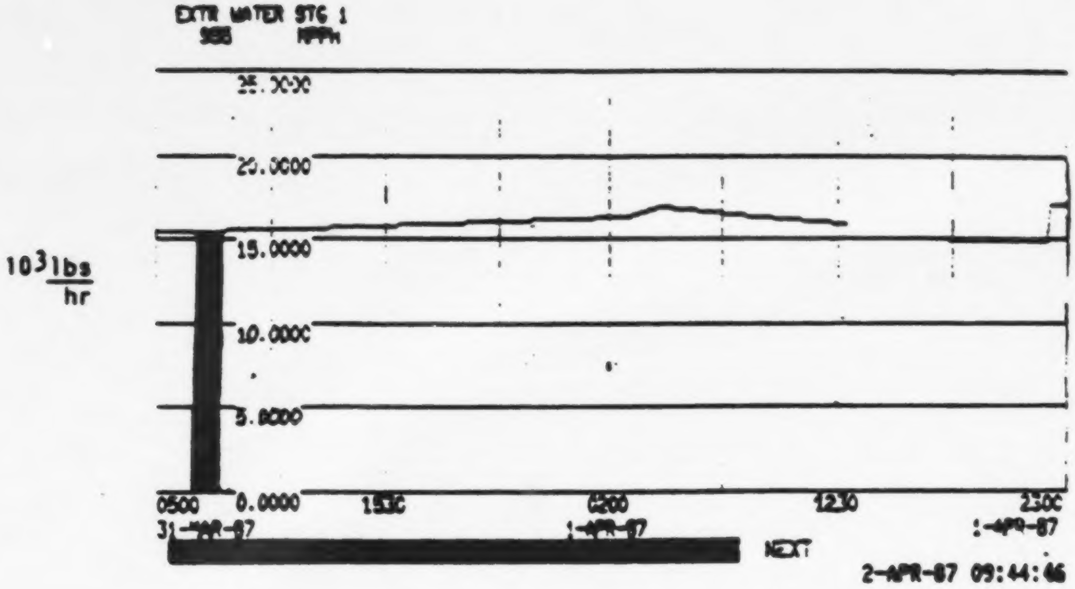


FEED RATE TO THE CARBON ADSORPTION SYSTEM

FIGURE G-5 RECORDING CHARTS FOR K103: SAMPLE SET #5 (Continued)

SAMPLE SET #1
March 31, 1987

7:00 - 8:00 AM

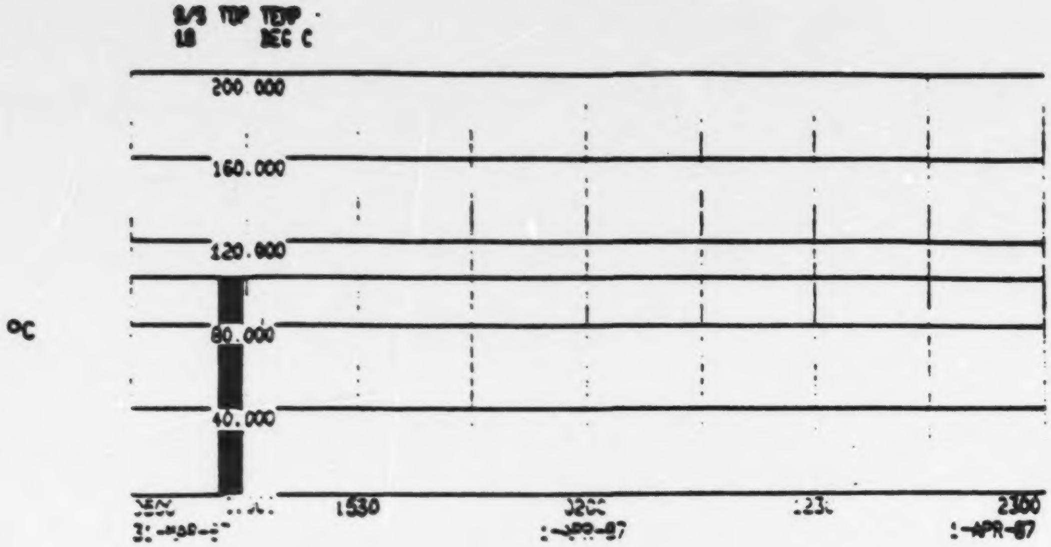


FEED RATE TO THE ANILINE LIQUID/LIQUID EXTRACTOR

FIGURE G-6 RECORDING CHARTS FOR K104: SAMPLE SET #1

SAMPLE SET #1
March 31, 1987

9:00 - 10:00 AM



STEAM STRIPPER TOP COLUMN TEMPERATURE

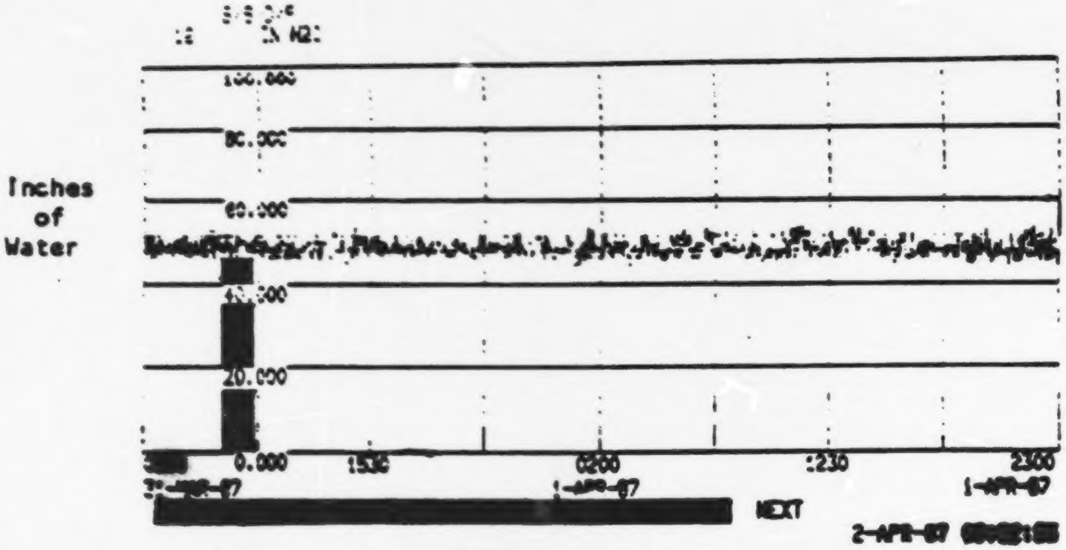
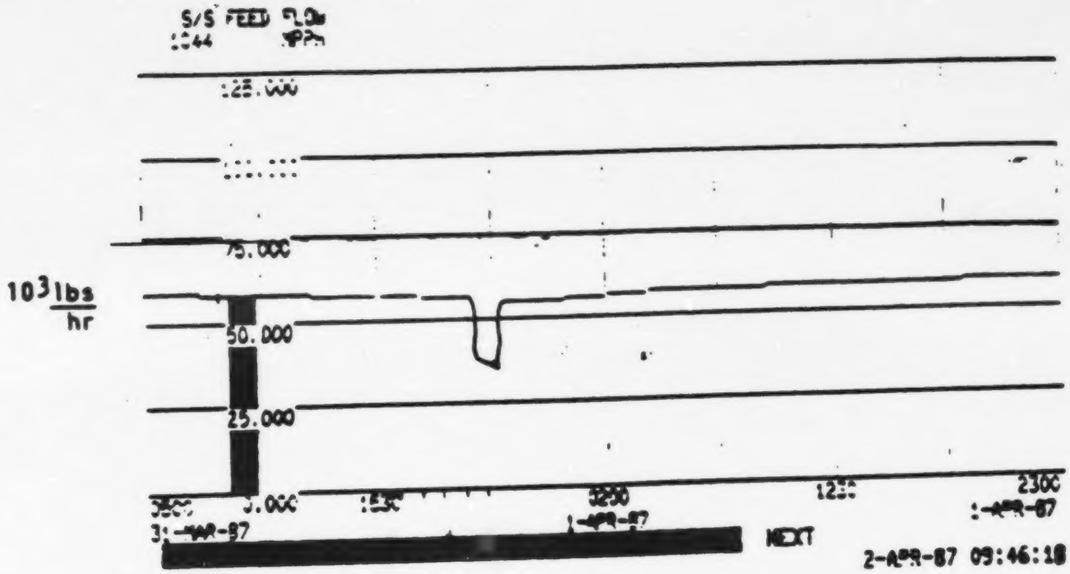


FIGURE II-5
PRESSURE DROP ACROSS THE STEAM STRIPPER COLUMN

FIGURE G-6 RECORDING CHARTS FOR K104: SAMPLE SET #1 (Continued)

SAMPLE SET #1
March 31, 1987

9:00 - 10:00 AM

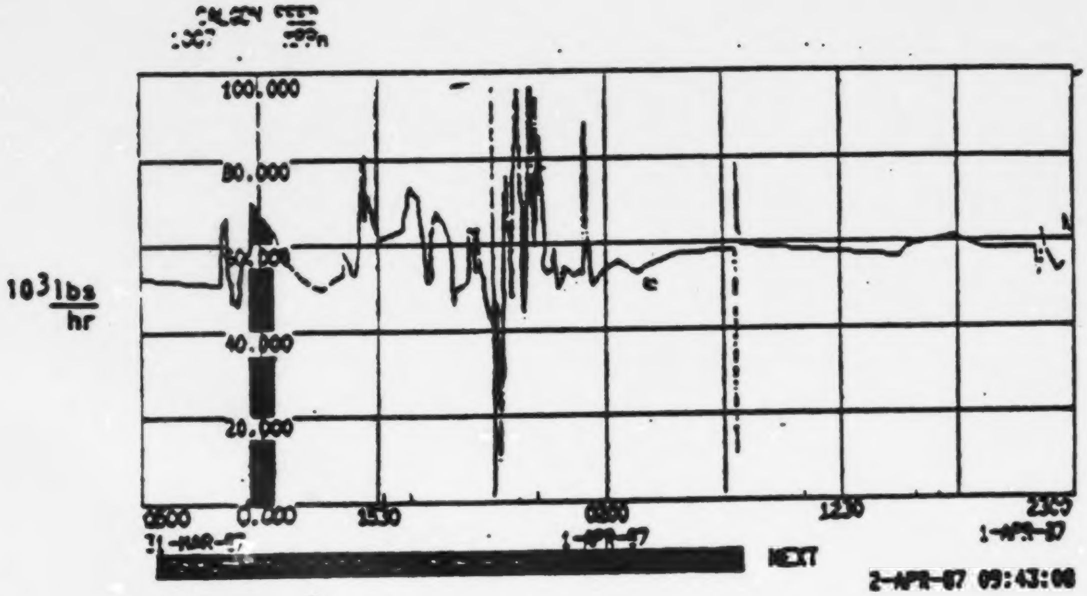


FEED RATE TO THE STEAM STRIPPER

FIGURE G-6 RECORDING CHARTS FOR K104: SAMPLE SET #1 (Continued)

SAMPLE SET #1
March 31, 1987

10:00 - 11:00 AM

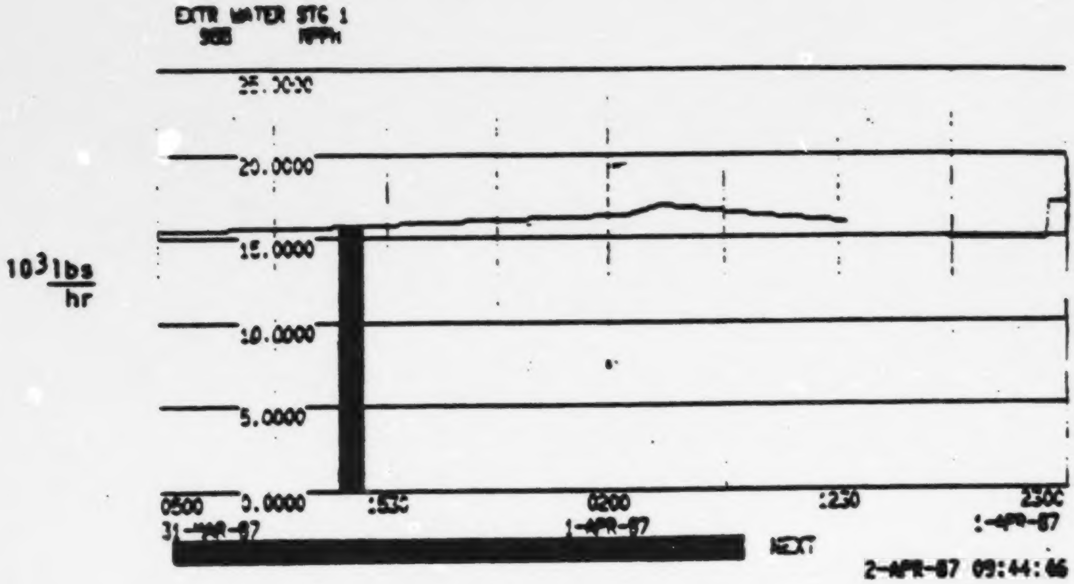


FEED RATE TO THE CARBON ADSORPTION SYSTEM

FIGURE G-6 RECORDING CHARTS FOR K104: SAMPLE SET #1 (Continued)

SAMPLE SET #2
March 31, 1987

1:00 - 2:00 PM

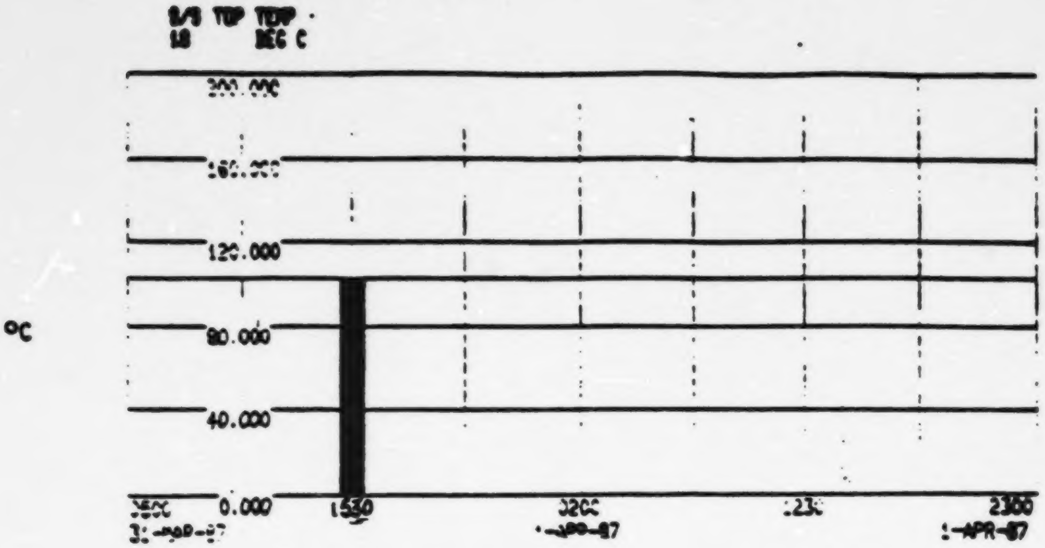


FEED RATE TO THE ANILINE LIQUID/LIQUID EXTRACTOR

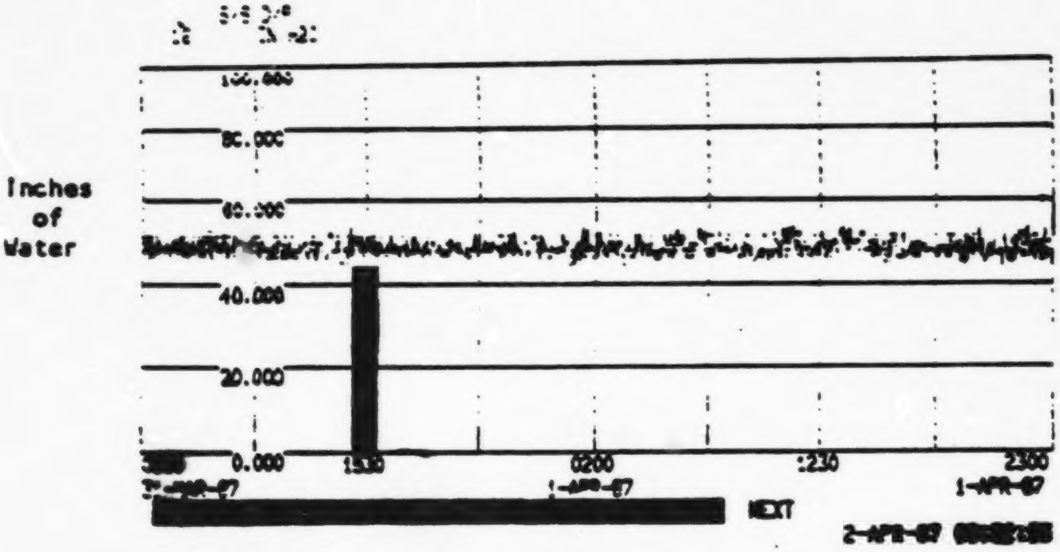
FIGURE G-7 RECORDING CHARTS FOR K104: SAMPLE SET #2

SAMPLE SET #2
March 31, 1987

3:00 - 4:00 PM



STEAM STRIPPER TOP COLUMN TEMPERATURE

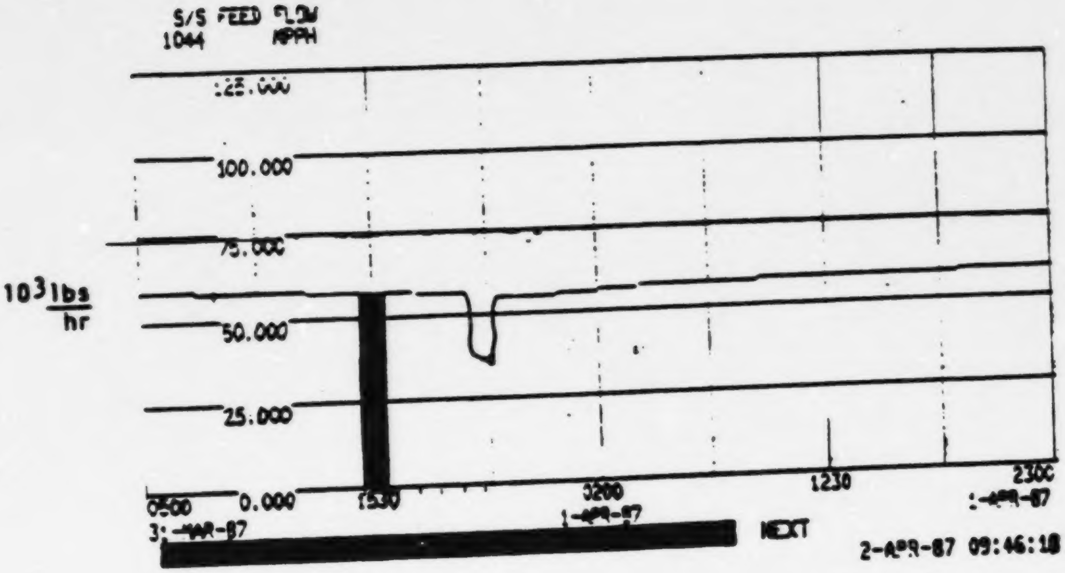


PRESSURE DROP ACROSS THE STEAM STRIPPER COLUMN

FIGURE G-7 RECORDING CHARTS FOR K104: SAMPLE SET #2 (Continued)

SAMPLE SET #2
March 31, 1987

3:00 - 4:00 PM

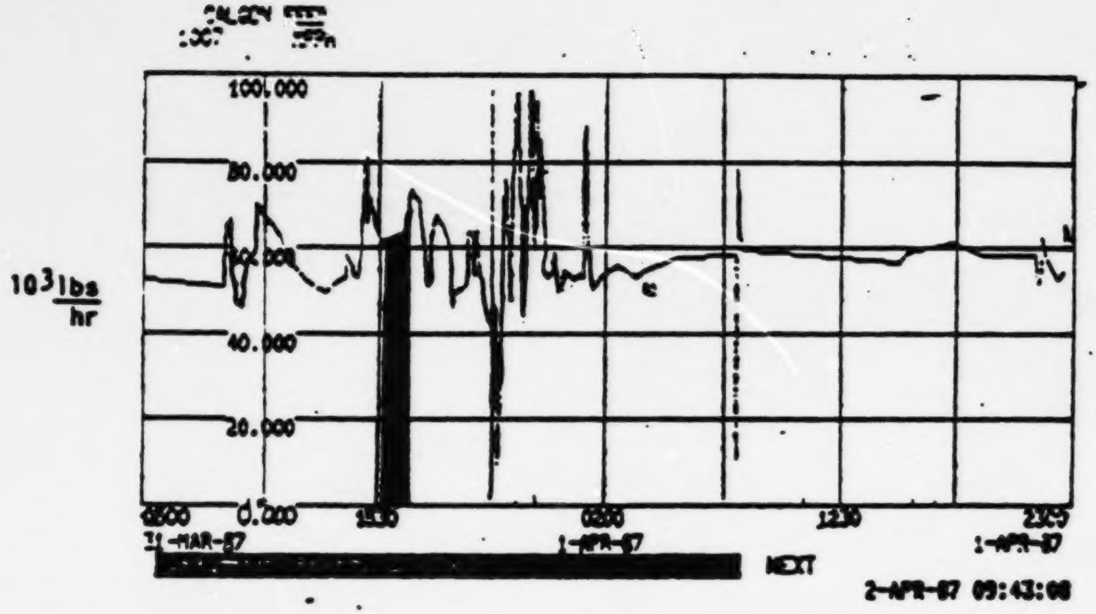


FEED RATE TO THE STEAM STRIPPER

FIGURE G-7 RECORDING CHARTS FOR K104: SAMPLE SET #2 (Continued)

SAMPLE SET #2
March 31, 1987

4:00 - 5:00 PM

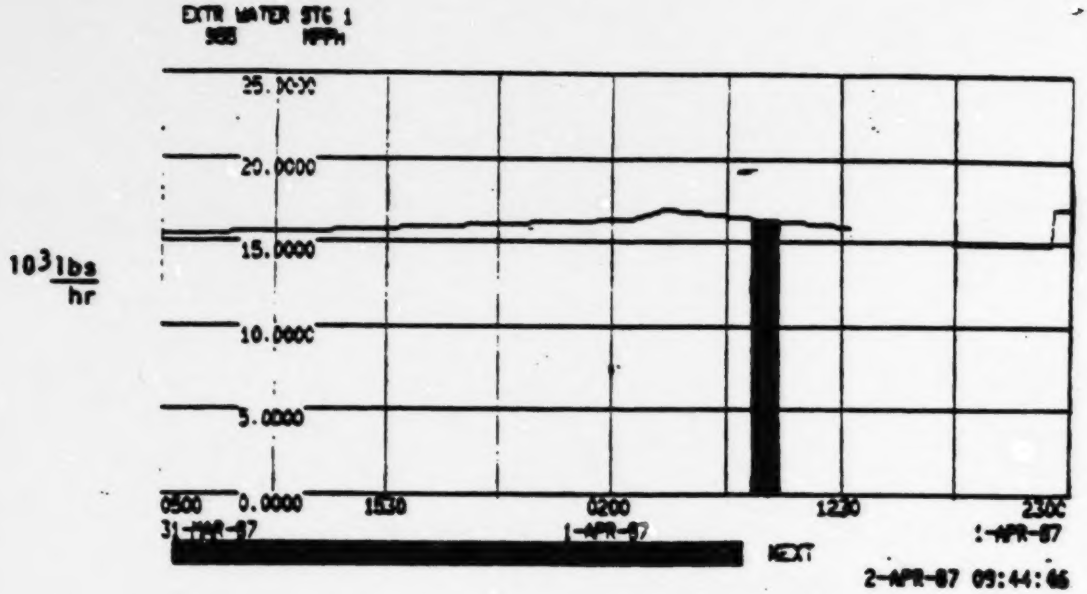


FEED RATE TO THE CARBON ADSORPTION SYSTEM

FIGURE G-7 RECORDING CHARTS FOR K104: SAMPLE SET #2 (Continued)

SAMPLE SET #3
April 1, 1987

7:00 - 8:00 AM

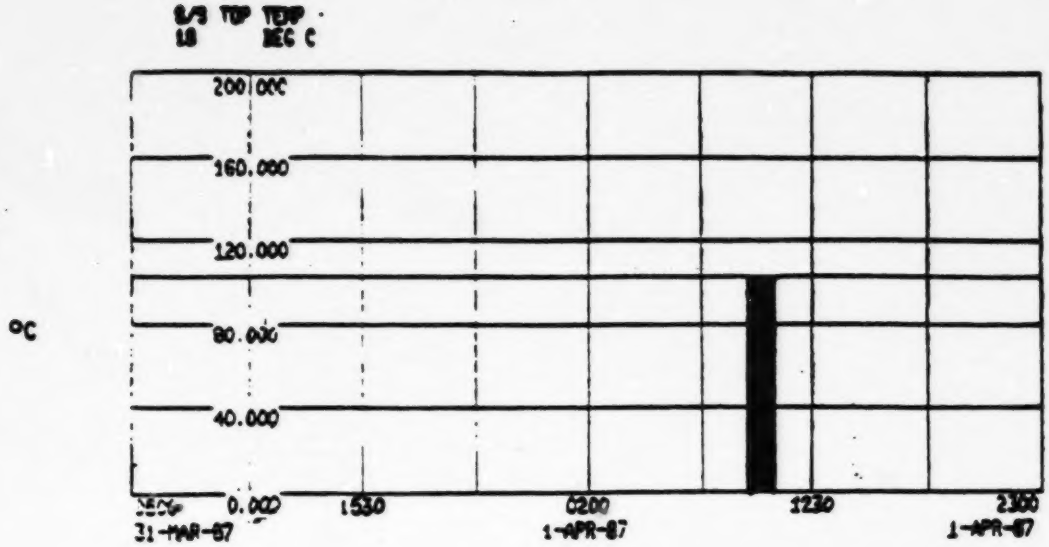


FEED RATE TO THE ANILINE LIQUID/LIQUID EXTRACTOR

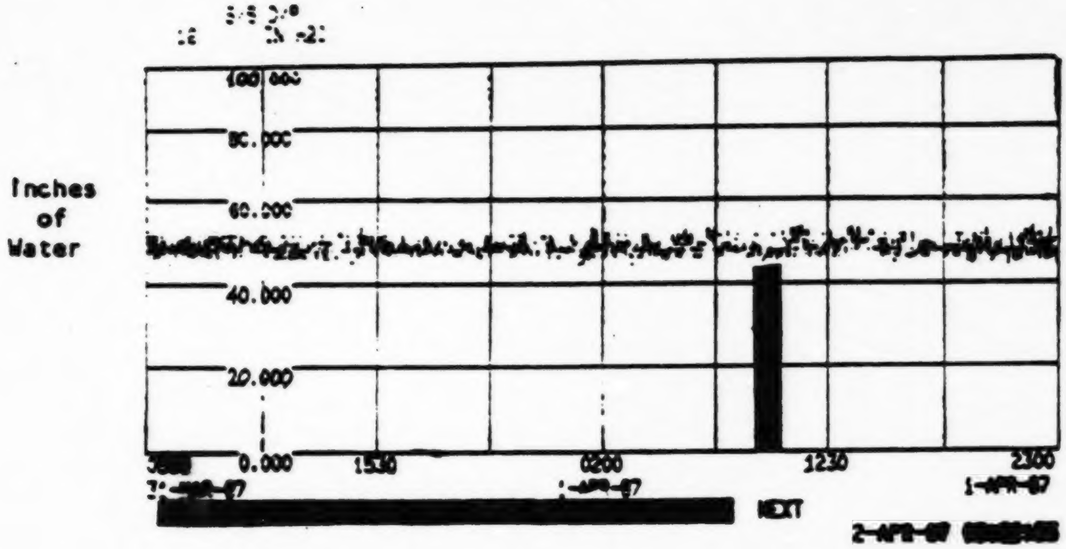
FIGURE G-8 RECORDING CHARTS FOR K104: SAMPLE SET #3

SAMPLE SET #3
April 1, 1987

9:00 - 10:00 AM



STEAM STRIPPER TOP COLUMN TEMPERATURE



PRESSURE DROP ACROSS THE STEAM STRIPPER COLUMN

FIGURE G-8 RECORDING CHARTS FOR K104: SAMPLE SET #3 (Continued)

SAMPLE SET #3
April 1, 1987

9:00 - 10:00 AM

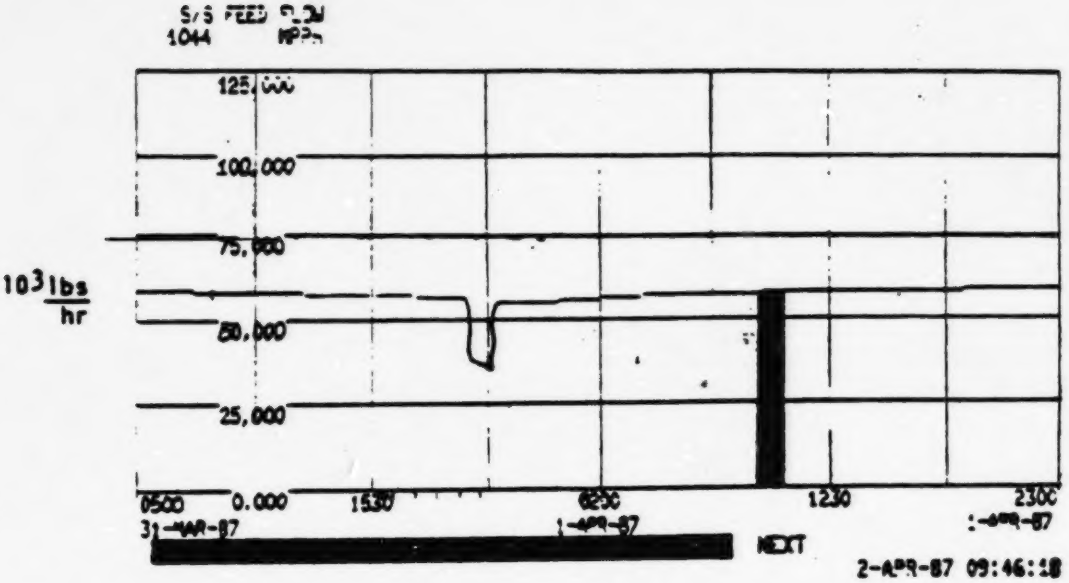
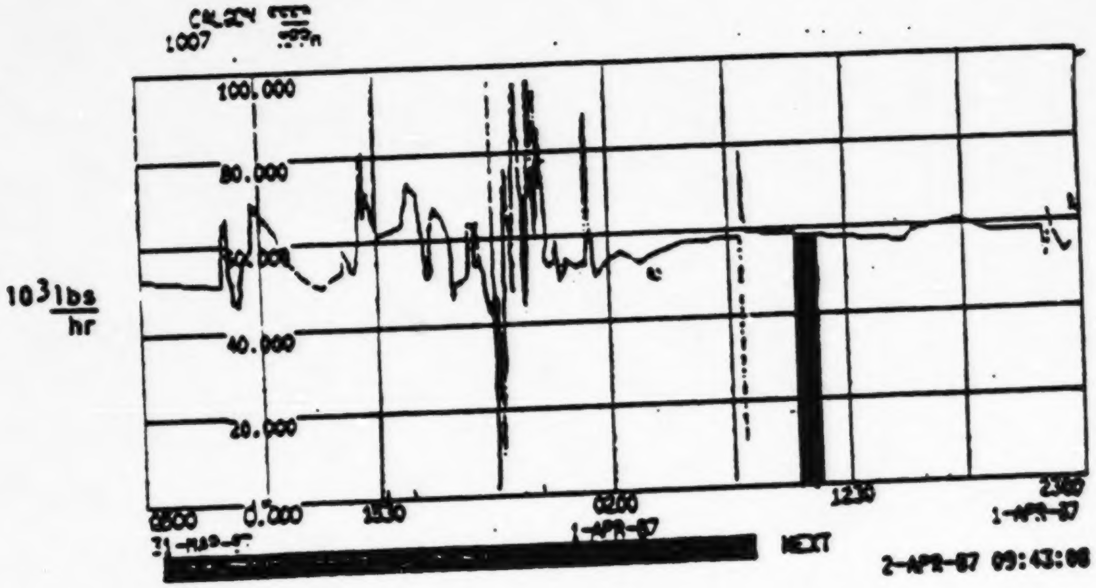


FIGURE 11-8
FEED RATE TO THE STEAM STRIPPER

FIGURE G-8 RECORDING CHARTS FOR K104: SAMPLE SET #3
(Continued)

SAMPLE SET #3
April 1, 1987

10:00 - 11:00 AM

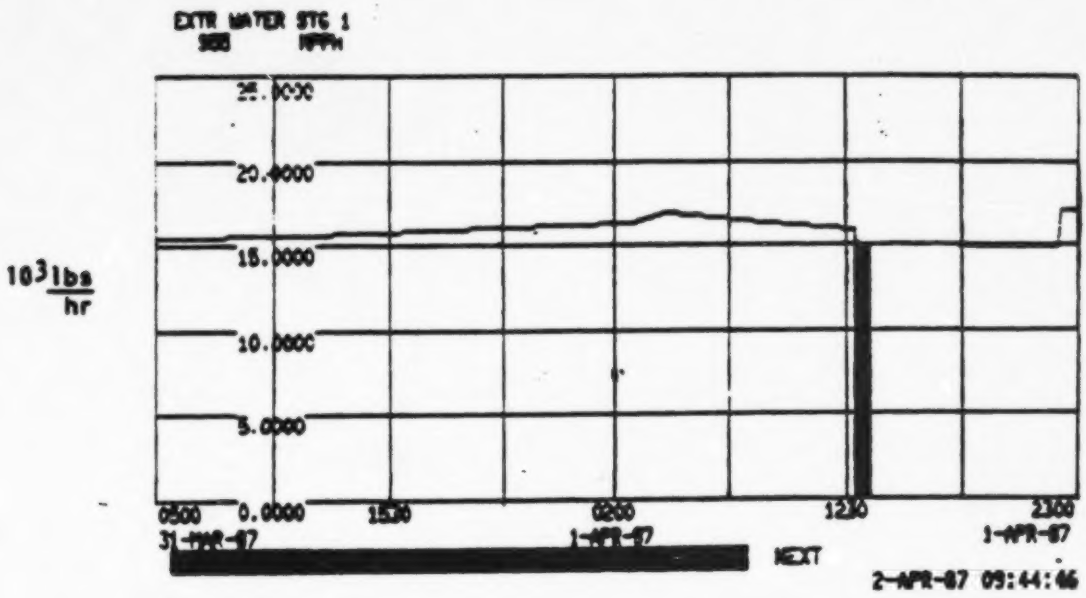


FEED RATE TO THE CARBON ADSORPTION SYSTEM

FIGURE G-8 RECORDING CHARTS FOR K104: SAMPLE SET #3 (Continued)

SAMPLE SET #4
April 1, 1987

1:00 - 2:00 PM

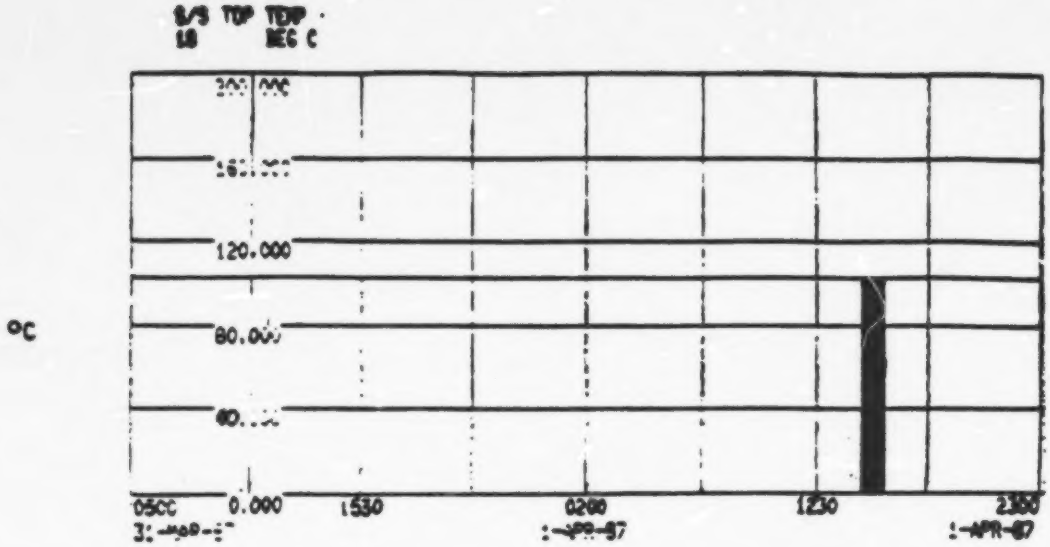


FEED RATE TO THE ANILINE LIQUID/LIQUID EXTRACTOR

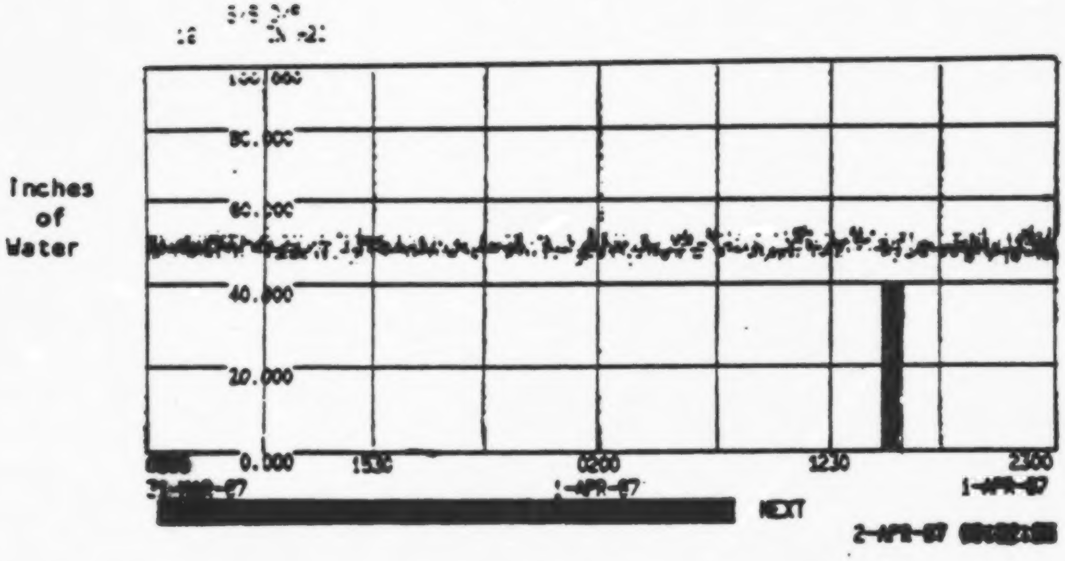
FIGURE G-9 RECORDING CHARTS FOR K104: SAMPLE SET #4

SAMPLE SET #4
April 1, 1987

3:00 - 4:00 PM



STEAM STRIPPER TOP COLUMN TEMPERATURE

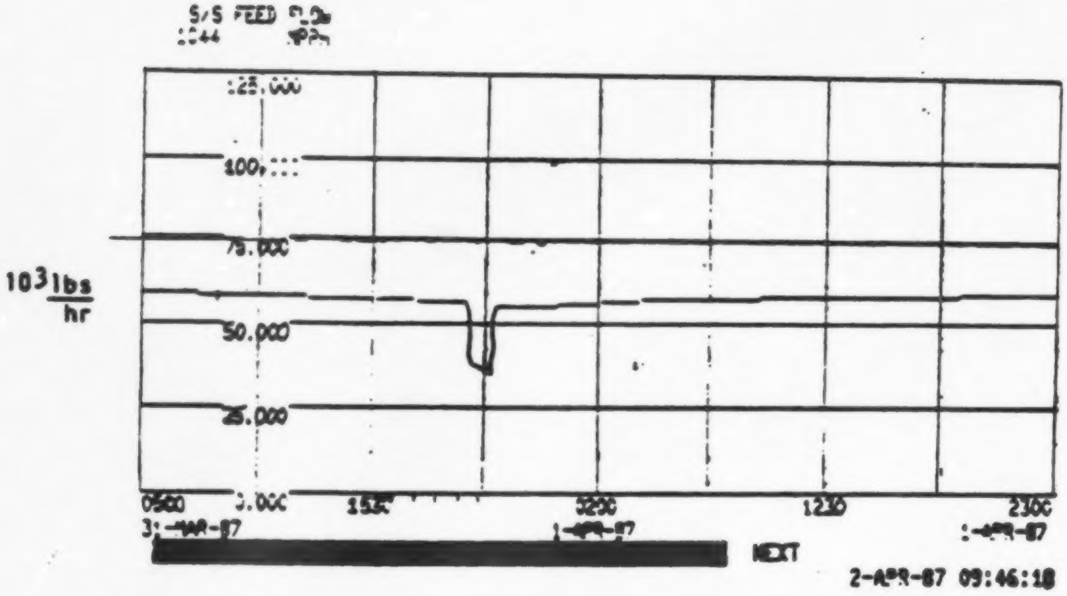


PRESSURE DROP ACROSS THE STEAM STRIPPER COLUMN

FIGURE G-9 RECORDING CHARTS FOR K104: SAMPLE SET #4 (Continued)

SAMPLE SET #4
April 1, 1987

3:00 - 4:00 PM

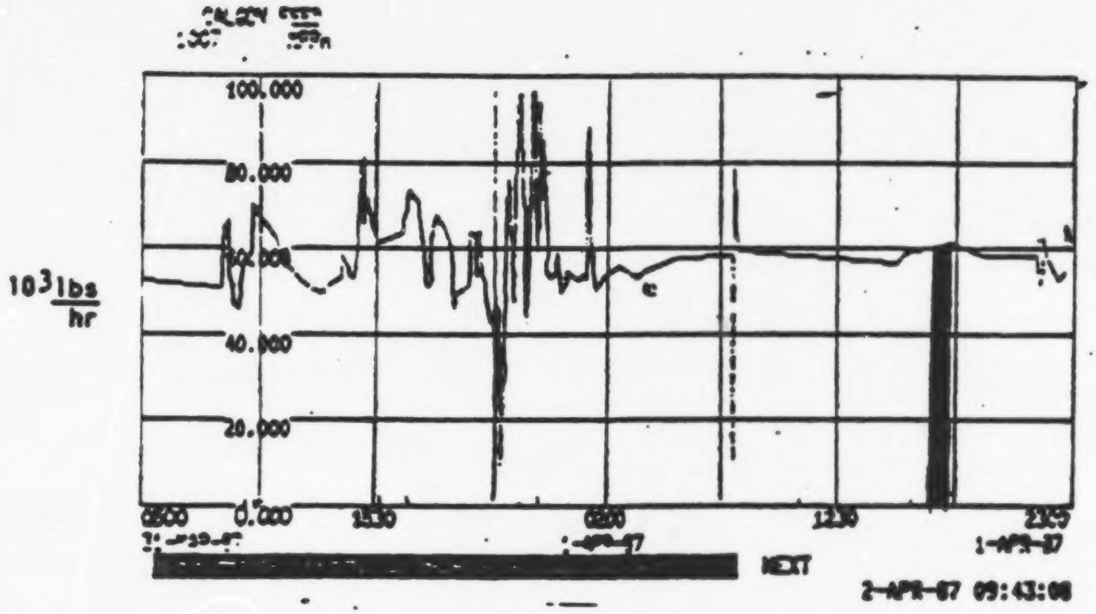


FEED RATE TO THE STEAM STRIPPER

FIGURE G-9 RECORDING CHARTS FOR K104: SAMPLE SET #4 (Continued)

SAMPLE SET #4
April 1, 1987

4:00 - 5:00 PM

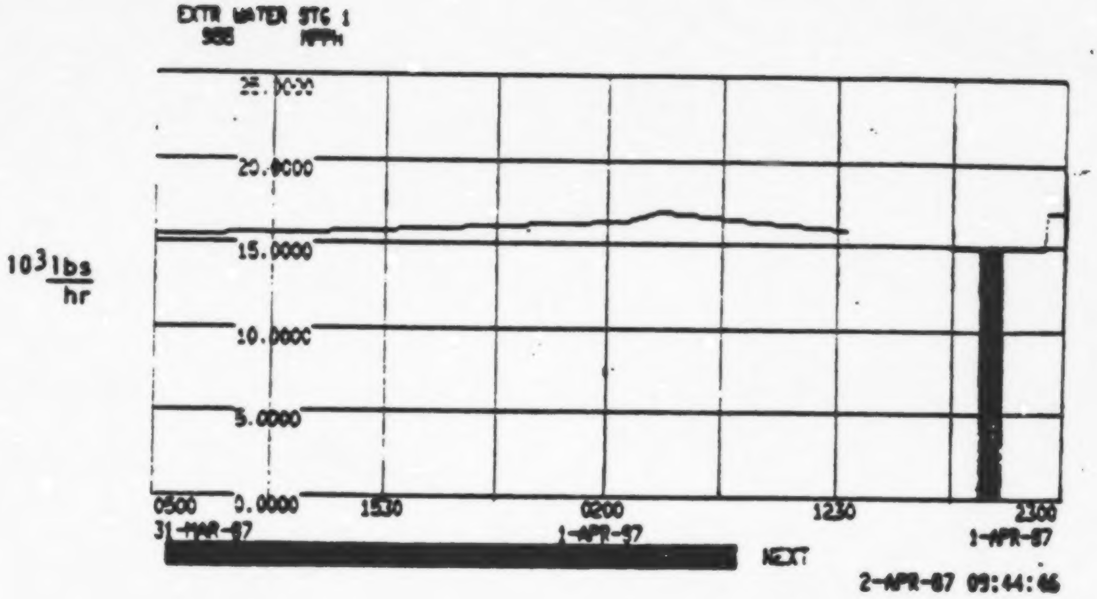


FEED RATE TO THE CARBON ADSORPTION SYSTEM

FIGURE G-9 RECORDING CHARTS FOR K104: SAMPLE SET #4 (Continued)

SAMPLE SET #5
April 1, 1987

7:00 - 8:00 PM

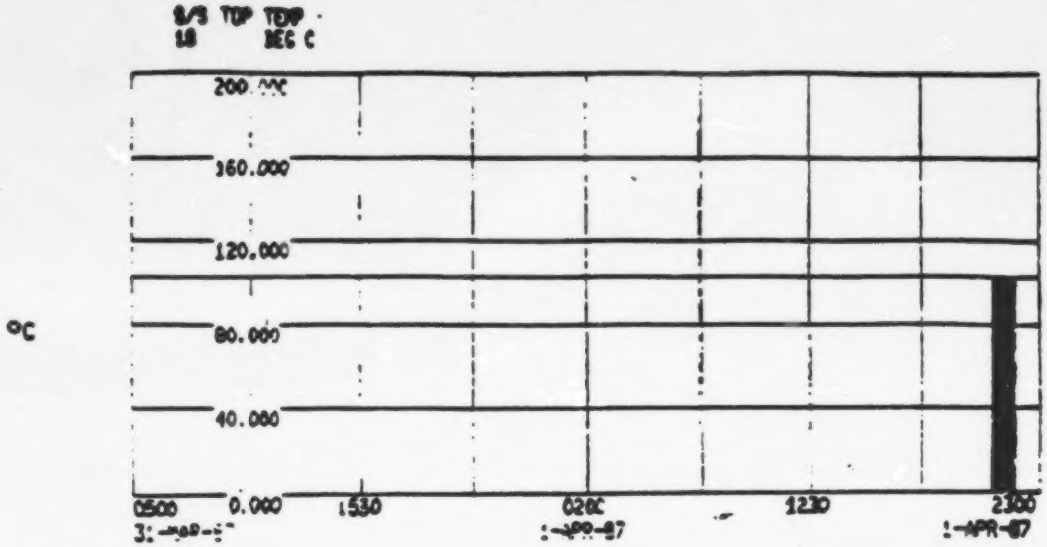


FEED RATE TO THE ANILINE LIQUID/LIQUID EXTRACTOR

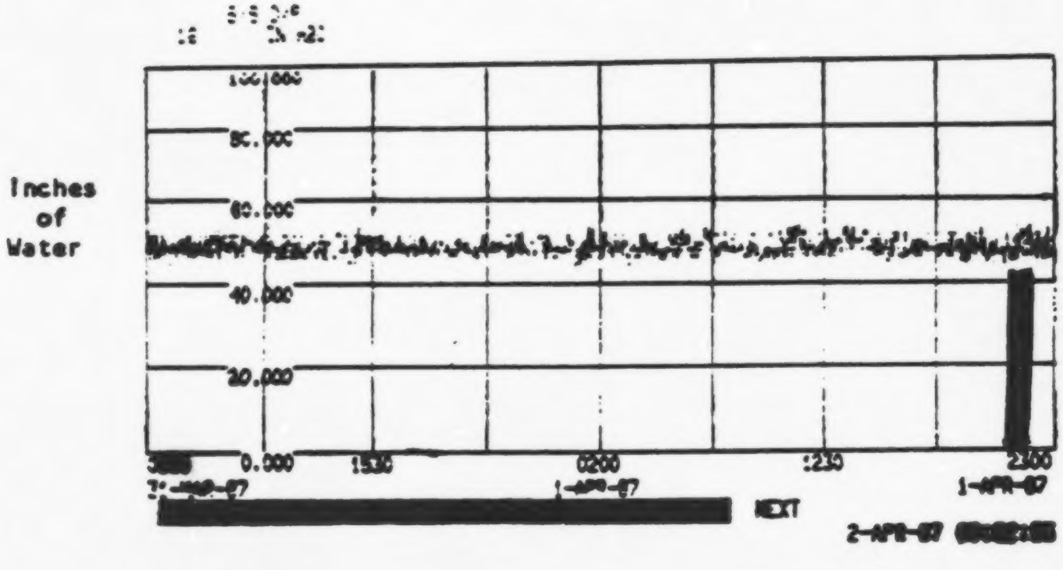
FIGURE G-10 RECORDING CHARTS FOR K104: SAMPLE SET #5

SAMPLE SET #5
April 1, 1987

9:00 - 10:00 PM



STEAM STRIPPER TOP COLUMN TEMPERATURE

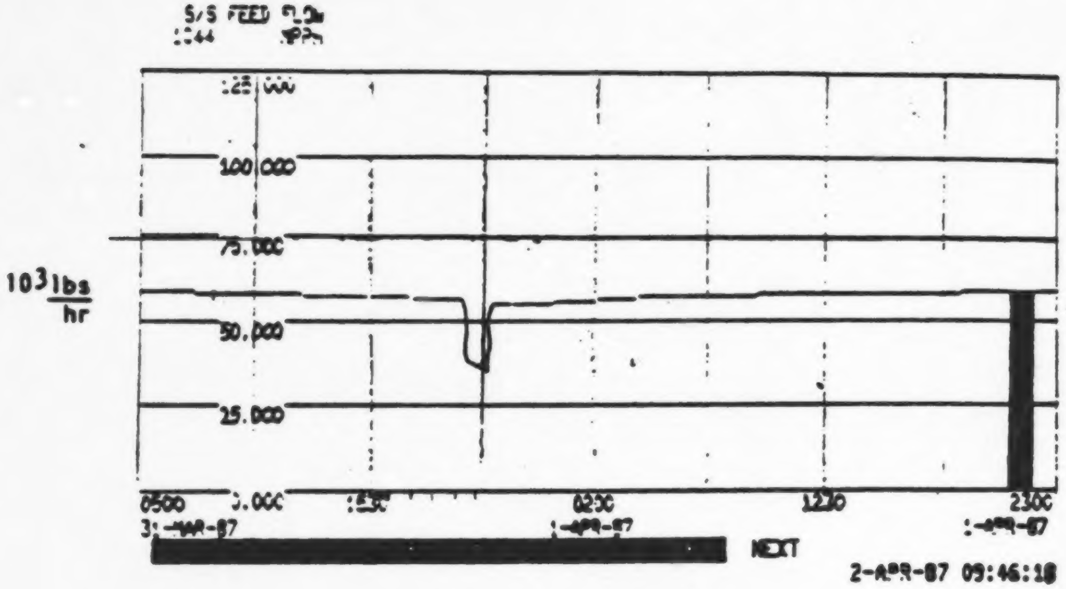


PRESSURE DROP ACROSS THE STEAM STRIPPER COLUMN

FIGURE G-10 RECORDING CHARTS FOR K104: SAMPLE SET #5 (Continued)

SAMPLE SET #5
April 1, 1987

9:00 - 10:00 PM

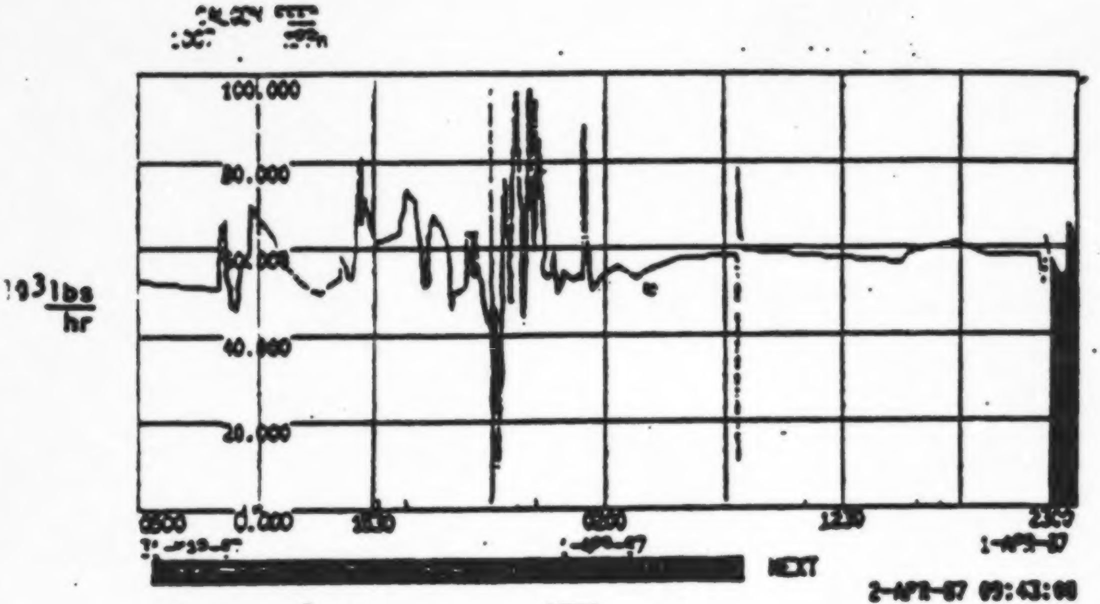


FEED RATE TO THE STEAM STRIPPER

FIGURE G-10 RECORDING CHARTS FOR K104: SAMPLE SET #5 (Continued)

SAMPLE SET #5
April 1, 1987

10:00 - 11:00 PM



FEED RATE TO THE CARBON ADSORPTION SYSTEM

FIGURE G-10 RECORDING CHARTS FOR K104: SAMPLE SET #5 (Continued)